A LOCAL SPATIAL DATA INFRASTRUCTURE TO SUPPORT THE MERAPI VOLCANIC RISK MANAGEMENT;
A CASE STUDY AT SLEMAN REGENCY, INDONESIA

By:
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Thesis submitted to the Graduate School, Faculty of Geography, Gadjah Mada University in partial fulfilment of the requirement for the degree of Master of Science in Geo-Information for Spatial Planning and Risk Management

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THESIS

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DISCLAIMER

This document describes work undertaken as part of a programme of study at the Double Degree International Programme of Geo-Information for Spatial Planning and Risk Management, a Joint Program of International Institute for Geo-Information Science and Earth Observation (ITC) – The Netherlands and Gadjah Mada University – Indonesia. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the institute.

Putra, T.Y.D

Abstract

Risk management of Merapi Volcano has been an important programme conducted by Sleman government in order to minimize damages and casualties. Utilization of spatial data and its technologies is a key for enhanced decision making and coordination in risk management activities. However, the current situation regarding spatial data availability, integration, sharing and its effective application by decision makers at Sleman government agencies have not been optimized.

This research aims to implement an application of a Local Spatial Data Infrastructure (SDI) to support risk management efforts, particularly for evacuation planning of Merapi Volcano disaster. SDI is an initiative intended to create an environment that will enable a wide variety of users to access, retrieve and disseminate spatial data resources effectively. One of the essential applications of SDI is geoportals.

The study started with a review on activities of risk management of Merapi Volcano. Spatial data needs and roles of the local government agencies were identified. Furthermore, the processes, problems and information flows in evacuation planning were examined. These prerequisites were analysed as foundation for the development of the application. Geocollaboration Portal (Aditya, 2008) was customized in order to provide spatial resources for decision makers when dealing with the evacuation process. It is equipped with usable maps presentation and interaction tools to support collaborative decisions.

Finally, user group assessment was carried out to evaluate usability of the application. The evaluation results showed that collaborative portals on top of a local SDI can facilitate effective decision making process and improve coordination among involved stakeholders in the context of disaster preparedness and mitigation. Nevertheless, there are several aspects need to be considered in order to achieve a functional local SDI e.g. availability and quality of the spatial data, establishment of local regulations and standards, development of metadata, and strengthening capable human resources.

Keywords: Merapi Volcano, Sleman, risk management, evacuation planning, local SDI, geoportals, user group assessment, usability.

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Glossary

Badan Kesbanglinmas Provinsi D.I. Yogyakarta	Provincial Agency for Nation Unity and Protection of Community
Bappeda	Local Agency for Planning and Development
Bakosurtanal	National Coordinating Agency for Survey and Mapping
Bidang Tapem	Government Administrative Unit of Regency Secretary
BKD	Local Agency for Employment
BPPD	Local Agency for Land Control
BPPTK	Research and Technology Development Agency for Vulcanology
BPKKD	Local Agency for Finance Management and Treasure
Bupati	Head of the Regency
Desa	Village
Dinas P3BA	Local Agency for Irrigation, Mining and Disaster Management
Dinas Kesehatan	Local Agency for Health
Dinas Kimpraswilhub	Local Agency for Housing, Infrastructure and Transportation
Dinas Nakersos & KB	Local Agency for Manpower, Social and Planned Family
Dinas Pendidikan	Local Agency for Education
Dinas Pol PP & Tibmas	Local Agency for Civil Police and Community Orderliness
Dusun	Sub-Village
GPS	Global Positioning Survey
Kabupaten	Regency
Kantor Telematika	Telecommunication and Information Office
Kecamatan	Sub-District
Kodim	District Military Command
NGO	Non-Governmental Organization
PDAM	Local Drinking Water Company
PLN	Local Electricity Company
Polres	Local Police Department
Puskesmas	Local Health Centre
Satlak PB	Local Executing Unit for the Management of Disaster
SDI	Spatial Data Infrastructure
VSI	Vulcanological Survey of Indonesia

1. INTRODUCTION

The first chapter describes general overview of this research, including background of the research, problem statement, research objectives, research questions , proposed innovations, research benefits, research limitations, research framework and thesis structure.

1.1. Background

Indonesia is vulnerable country prone to natural disasters due to its geographical and geological conditions. It is located on the edge of the Pacific, Eurasian, and Indo-Australian tectonic plates which is the place of abundant volcanoes and frequent earthquakes. Indonesia has at least 129 active volcanoes with numerous victims and damages recorded in the historic eruptions. Within the period of 1900-2008, Indonesia has experienced 48 volcanic eruptions with more than 17,900 people killed and approximately US$ 344 million economic losses were recorded (EM-DAT, 2009).

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 it reveals more than one volcanic hazards. Merapi flanks are also home of dense population in Central Java Province and Special Region of Yogyakarta. Disaster risk management of Merapi Volcano is indispensable to protect the endangered population. The location of Merapi Volcano is presented in Figure 1.1. Based on the facts above, 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.

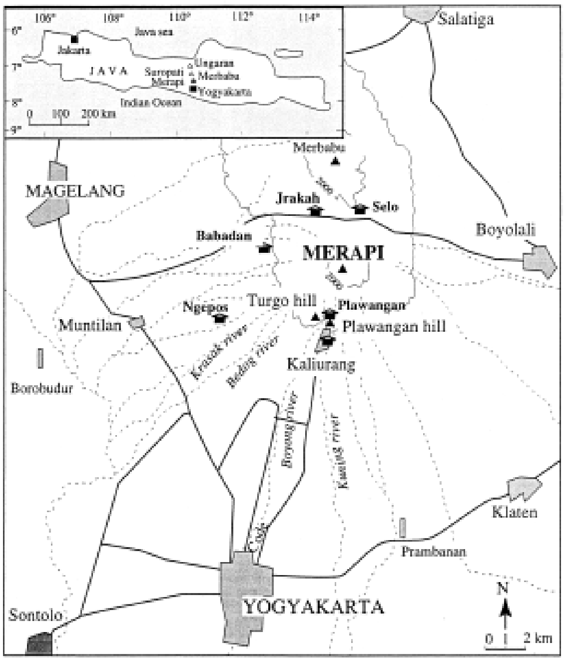


Figure 1-1: Site map of Merapi Volcano (Voight, B. et al., 2000)

The potential utilization of spatial data and its technologies for disaster management activities is extensively described (van Westen and Georgiadou, 2001; Mansor et al., 2004). Remote sensing provides information over large areas within short time intervals and can be used as parameter in the study of disasters. Geographic Information System (GIS) analyze and calculate those data to generate hazards and risk map, modelling risk scenarios and other activities in risk management. Local and national agencies incorporate spatial data with statistical and social data, to construct hazard identification, preparation and mitigation plans, response actions and also reconstruction programs.

Unfortunately, in the Indonesian disaster management context many of these data are seldom used, even if they were available. One explanation is that the data are not yet standardized which leads to a lack of harmonization of datasets (Kompas, 2005). If each agency tries to collect their own required data and develop information products with their own specifications and codifications, consequently, data sharing and integration of different spatial data produced by agencies involves in disaster management cannot be established. One advocated solution strategy is therefore 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 and could potentially improve utilization of spatial data for disaster management.

1.2. Problem Statement

Disaster risk management needs spatial data which are currently hosted by agencies at both local and national level. In the context of Merapi volcanic risk management, in the development of risk map of Merapi Volcano, local government of Sleman Regency need spatial data from various national agencies, including the Research and Technology Development Agency for Vulcanology (BPPTK), National Coordinating Agency for Survey and Mapping (Bakosurtanal) or National Agency on Meteorology, Climatology and Geophysics (BMKG). Such a local agency typically needs to combine those data with thematic data, collected by local agencies (such as Housing, Infrastructure and Transportation Agency, Health Agency or Local Planning Agency). Other similar examples of vertical and horizontal data needs could be seen in the determination of the evacuation routes or refuges relocation plan. This planning requires data from different stakeholders (including Non-governmental Organizations (NGOs)) at different levels of authority.

At this point problem might be arise since each organization may have different data contents and sources, different spatial data model, and different software platform (Gong et al., 2004). Besides that, local agencies were often not utilize data from national agencies due to the lack of internet infrastructure so they are unable to download the data, or simply because the data is not free and they have no budget to buy it (de Vries, 2006). Consequently, this can lead to inexistence of data sharing and data integration among organizations involved in Merapi volcanic risk management activities.

Previous study found that SDI is not yet implemented to help decision-making processes of disaster management. According to Aditya (2008), although local authorities have realized the importance of spatial data and GIS in supporting their tasks, its utilizations are still low. Maps are only generally used as a means to share and distribute the information among local government agencies. For analysis, synthesis and collaborative activities its deployment are hardly recognized. Furthermore Mansourian et al. (2006) and Aditya (2008) have found that an SDI can be used to facilitate collaboration efforts among local government agencies in dealing with disaster mitigation and responses.

Based on the facts identified in preceding paragraphs, this research was investigating problems in accessing, sharing and integrating spatial data at local government. The study also was explored how a local SDI can be implemented to support utilization of maps for analysis, particularly for Merapi volcanic risk management activities. Sleman Regency is selected as study area because it is closely located to Merapi Volcano and the local government has established agency for disaster management (Dinas Perairan, Pertambangan dan Penanggulangan Bencana Alam) since 2003.

1.3. Research Objectives

Main objective

The main objective of this research is to design and test an application of a local SDI for the Merapi volcanic risk management activities conducted by local government of Sleman Regency.

Specific objectives

a. To describe which Merapi volcanic risk management activities rely on spatial data in the Sleman Regency;
b. To identify which functionalities of SDI are required by which agencies at local level in supporting Merapi volcanic risk management;
c. To develop an application of a local SDI for Merapi volcanic risk management based on those functionalities and requirements;
d. To test the application of a local SDI by creating a prototype system and evaluate it with the user.

1.4. Research Questions

With the purpose of achieving research objectives, the following research questions are summarized in Table 1-1 below.

Table 1-1: Research objectives and research questions

No.	Research Objectives	Research Questions
1.	To describe which Merapi volcanic risk management activities rely on spatial data in the Sleman Regency	a. What are Merapi volcanic risk management activities at Sleman Regency? b. What spatial data are needed and available in conducting Merapi volcanic risk management? c. Which organizations/agencies are involved in Merapi volcanic risk management at Sleman Regency? d. How does the local government construct evacuation planning of Merapi Volcano disaster?
2.	To identify which functionalities of SDI are required by which agencies at local level in supporting Merapi volcanic risk management	a. What are the components and structure of a local SDI? b. What is (if it exists) the condition of local SDI at Sleman Regency? c. What kind of local SDI functionalities are needed by agencies to support the evacuation planning of Merapi Volcano disaster?
3.	To develop an application of a local SDI for Merapi volcanic risk management based on those functionalities and requirements	a. How to design an application utilizing a local SDI suited for evacuation planning of Merapi Volcano disaster? b. Which technologies can be used to implement the application of a local SDI at Sleman Regency? c. How to implement the prototype based on requirements of the user?
4.	To test the application of a local SDI by creating a prototype system and evaluate it with the user	a. How to evaluate the usability of the prototype? b. What are the results of the usability assessment? c. What improvement should be done to the next prototype development based on the users' expectations?

1.5. Proposed Innovations

a. The application was developed on scenario-based approach, particularly for evacuation planning.

b. Test was included user focus groups evaluation, allowing an incremental implementation method.

1.6. Research Benefits

a. Problems identification and solution in spatial data access, sharing, and integration, particularly on Merapi volcanic risk management activities.

b. Establishment of a local SDI for Merapi volcanic risk management will bring advantages, include:

- ☑ Reducing duplication of efforts related to the risk management activities among national and local government agencies;
- ☑ Reducing costs of spatial data acquisition because with local SDI it is possible to create the data only once then use many times;
- ☑ Making spatial data more accessible among involved stakeholders and to public or community.

c. Results of the research can be used as best practice of SDI implementation particularly for volcanic risk management in Indonesia.

1.7. Research Limitations

a) SDI is a complex system incorporates data, standard, technical, institutional and legal arrangements. This study mainly discusses the technical aspect associated with the implementation of a local SDI. In this respect institutional and legal set up of local SDI is not the aim of the research.

b) The risk management activities for Merapi Volcano were used as proof of concept of local SDI deployment. However not all risk management activities were generated for the implementation. This research focused on the activity of evacuation planning of Merapi Volcano disaster.

c) Testing participants was limited only to the local government agencies of Sleman Regency which involved in the evacuation planning of Merapi Volcano disaster. Usability of the prototype were tested in four aspects namely usefulness, effectiveness, satisfaction and accessibility.

1.8. Research Framework and Thesis Structure

Research Framework

Methodology of the research is presented in Figure 1-2. It consists of four phases as follows:

I. System Requirements

This phase aims to acquire requirements from all stakeholders involved in Merapi volcanic risk management activities as a basis for the development of application of Local SDI. Another purpose is to identify which functionalities of SDI are required by those agencies. There are two main activities, firstly is analyzing current risk management activities and secondly investigate existence of local SDI at Sleman Regency.

After completion of this phase, overall system requirements which include user and technical requirements should be listed. Besides that another important aspect that needs to be included is the existing system. One of the considerations of SDI implementation stated by Georgiadou et al.

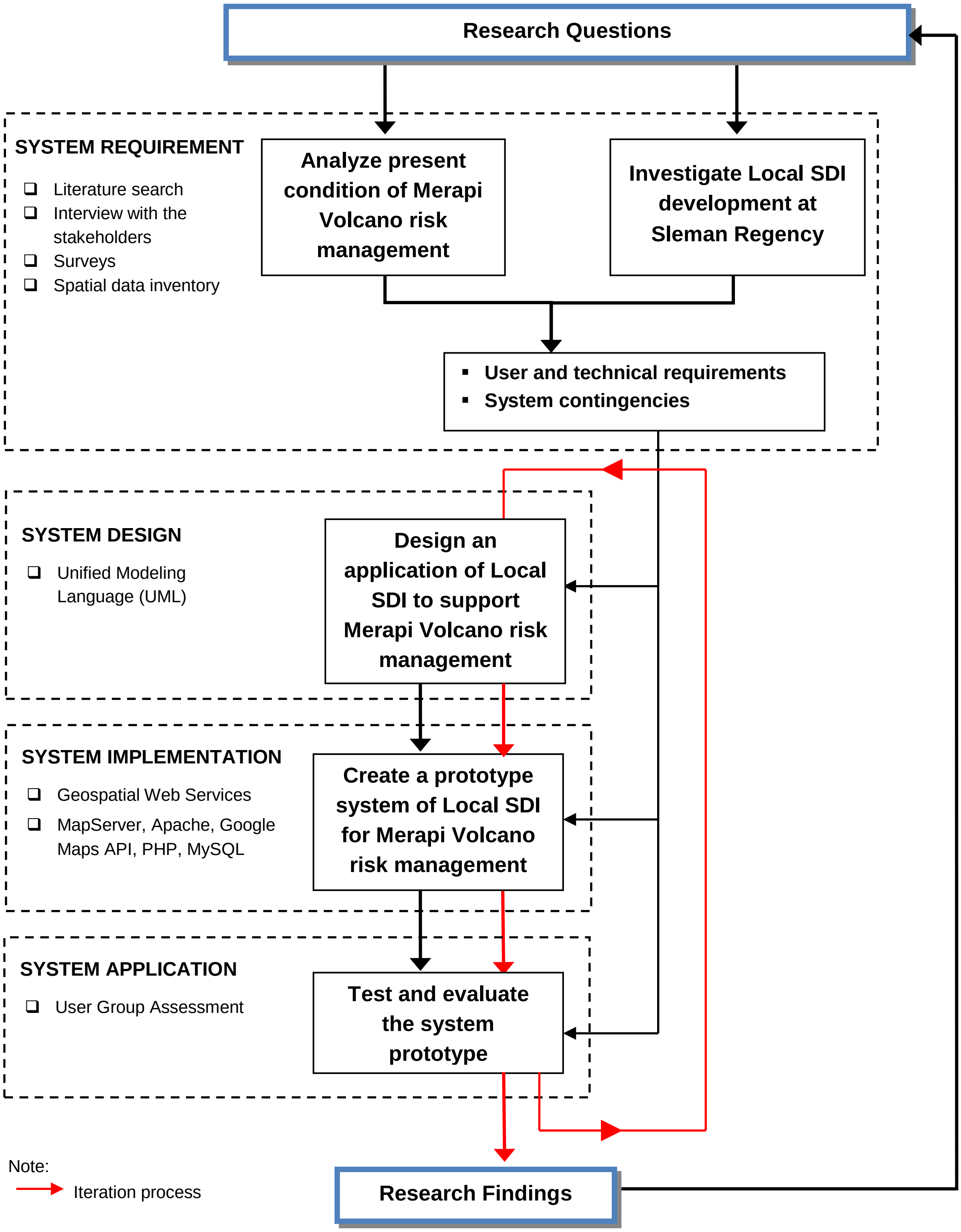


Figure 1-2: Research framework

(2005) is cultivation approach to design which represented by system contingency. It means the design should be build upon existing systems and establishing SDI should also consider them. As we can see from Figure 1-2 the system requirements will affect all the next phases, this implied an iterative process. However the iteration will be conducted only one time due to the limited moment of the research.

II. System Design

This phase aims to design the application of a local SDI based on the requirements gathered from previous phase. The application is particularly designed for supporting risk management activities of Merapi hazards. It will be designed using UML.

III. System Implementation

This phase aims to implement the proposed local SDI design from previous phase by deploying geospatial web services, particularly WMS and KML. The author utilized GeoCollaboration Portal (Aditya, 2008) for system implementation. The Portal was developed using PHP, MySQL, and *Google Maps Application Programming Interface (API).*

IV. System Application

This phase aims to test and evaluate the system prototype and find out its suitability to the stated requirements. The method employed for the evaluation is user group assessment. Sample of users will be selected to achieve the feasibility of proposed system in respect to risk management activities of Merapi Volcano. There are several issues will be investigated including usability and accessibility.

Thesis Structure

This research contains of eight chapters. Each chapter is explained briefly as follows:

Chapter 1 – Introduction

This chapter describes general overview of this research, including background of the research, problem statement, research objectives, research questions , proposed innovations, research benefits, research limitations, research framework and thesis structure.

Chapter 2 – Literature Review

This section provides conceptual background from available literatures correlated to this research.

Chapter 3 – Methodology

This chapter explains about method of the research being conducted. It describes fieldwork preparation, fieldwork process, data analysis, design process, and development of the prototype.

Chapter 4 – Merapi Volcanic Risk Management at Sleman Regency

This part will discuss about Merapi volcanic risk management, including activities of the risk management, institutions involved and what spatial data are needed. In addition it also explains about evacuation planning as part of the risk management conducted at Sleman Regency.

Chapter 5 – Local Spatial Data Infrastructure at Sleman Regency

This chapter identifies existence of local SDI at Sleman Regency based on information collected in the fieldwork. Discussion will be based on SDI components consist of regulation, institutional arrangements, data, technology and human resources.

Chapter 6 – Design and Implementation of the prototype

This section describes requirements from the respondents related to evacuation planning. Based on these requisites design of the prototype was constructed. Last section discusses about implementation of the prototype.

Chapter 7 – Evaluation of the Prototype

This chapter provides results of user group assessment on the prototype. Evaluation on usability aspects, specifically usefulness, effectiveness, satisfaction and accessibility will be discussed.

Chapter 8 – Conclusions and Recommendation

This part provides conclusions of the study results and recommendation for further research.

2. LITERATURE REVIEW

This chapter reviews theoretical background to support the study. It explains the hazards of Merapi Volcano, volcanic risk management, conceptual highlight on Spatial Data Infrastructure, and Spatial Data Infrastructure trajectories.

2.1. Merapi Volcanic Hazards

Merapi Volcano, positioned on the border between Central Java Province and Special Region of Yogyakarta, is the most active volcano in Indonesia. Based on historical data, Merapi has erupted regularly since 1006. From its first eruption Merapi has exploded more than 80 times. In the 17th century Merapi was produce one large explosion, resulting more than 3,000 people dead (Hadikusumo, 1970). There are several big explosions in following decade such as in 1822 which destroyed 8 villages and in 1837 when new dome appeared, replacing the old one (Voight, B. et al., 2000). Latest eruption of Merapi was on June 2006 produced pyroclastic flows, or "*awan panas*" in Indonesian, and killed 2 people. They were buried in a bunker when trying to escape from the danger.

Volcanic hazards can be classified into primary and secondary hazards (Smith and Petley, 2009). In the context of Merapi Volcano, the primary hazards that related to the products generated directly by the volcanic eruption are pyroclastic flows, lava flows and volcanic gasses. The secondary hazards generated by the material flow from the eruption and combine with other factors such as rainfall and over-steepening slopes. Ground deformation, lahars, and landslides are the examples.

Most of Merapi eruption has low explosivity and usually followed by pyroclastic flows. Newhall et al. (2000) distinguished two types of Merapi's pyroclastic flows. First type is called "Explosion pyroclastic flows" that originate from explosive eruptions, mostly by collapse of vertically-directed explosions. Local term for this pyroclastic flows type is "*awan panas letusan*". Their deposits are typically rich in scoriaceous breadcrust bombs. The second type is "Dome-collapse pyroclastic flows" originate by gravitational failure of lava domes. Synonym of this type in Indonesian is "*awan panas guguran*". The pyroclastic flows and surges usually reach about 8 to 9 km from the summit and at approximately 20 km, they are mixed with lahars and tephra deposits. Pyroclastic flows have caused many victims and losses. For instance on 22 November 1994, they were responsible for damages in Kaliurang and Turgo areas and kill over 60 people as well (Itoh et al., 2000).

Lahars of Merapi are common threat to the surrounding inhabitants. Since the beginning of 20th century, not less than 35 lahars' events caused damage on the slopes of Merapi. Historical data recorded more than 70 people were died and thousand of houses were destroyed, as well as tens of bridges (Lavigne et al., 2000).

Lahars at Merapi are generally triggered by heavy rainfall on the slopes, where pyroclastic deposits from recent eruption exist. Lavigne et al. (2000) distinguished Merapi's lahars type into hot and cold. Rainfalls or collapsed crater lakes that happened soon after the eruption will generate hot lahars. According to historical data, at least eight hot lahars incidents were reported since the mid-1500s. Meanwhile if rainfalls happen after some periods, cold lahars will be produced. One example is in 1994, after dome-collapse pyroclastic flows eruption there were 21 cold lahars events in Boyong River during the first rainy season.

2.2. Volcanic Risk Management

Disaster risk management term refers to a series of process relating administrative directives, organizations, operational skills, and capacities in order to reduce the adverse effects of hazards. It is initially proposed by United Nations through the International Strategy for Disaster Reduction (UNISDR). This term is an extension of the more general term "risk management" to address the specific issue of disaster risks. In The Traditional Disaster Management Cycle, risk management often considered to be focused upon the prevention, mitigation and preparedness stages as presented in Figure 2-1, even though prevention is seldom achievable (Smith and Petley, 2009).

In the context of volcano disaster, the risk management is aim to avoid, lessen or transfer the consequences of volcanic hazards through actions and measures. Risk management of a volcano is exceptionally complex because it can involve different hazardous phenomena including pyroclastic and lava flows, fallout of ash and tephra, lahars, or landslides. The approach involves the following set of activities:

- ❑ Volcanic hazards assessment including hazard identification and hazard map development. Output of this assessment is hazards map for each hazard types.
- ❑ Vulnerability assessment including identification of elements at risk near the volcano and determination of the vulnerability. This process will provide the vulnerability map.
- ❑ Risk assessment to determine the extent of risk by incorporating hazards and vulnerability assessment together with the coping capacities. Risk map is created based on the hazard and vulnerability maps.
- ❑ Establishment of early warning system to inform the community threatened by volcanic hazards, thus they can act properly and reduce the probability of harm and loss.
- ❑ Creation of evacuation plans including evacuation map, medical facilities and temporary shelter location.
- ❑ Determination of relocation area for the casualties.
- ❑ Development of the community awareness in dealing with volcanic hazards.

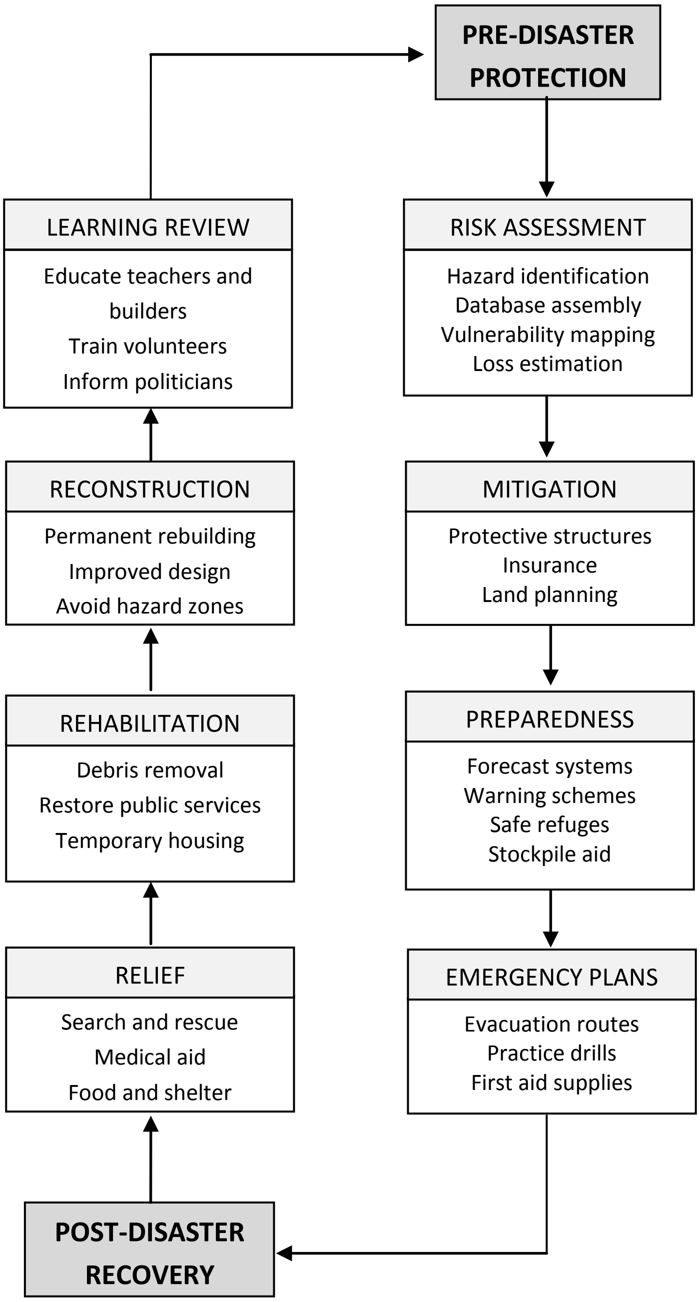


Figure 2-1: The management of disaster through pre-disaster protection and post-disaster recovery activities (Smith et al., 2009)

2.3. Conceptual Highlights on Spatial Data Infrastructure

Various definitions of SDI from organizations and researchers imply its complexity. SDI is more than technological infrastructure to provide spatial data resources. For example, Nebert (2004) in The SDI Cookbook defined SDI as a set of political, technological, and institutional frameworks to facilitate spatial data availability, access, and utilization. SDIs provide a basis for spatial data discovery, evaluation, and application for all different organization levels (e.g., regional, national, or local level). Meanwhile different term is used by European Committee (EC) who defined 'Infrastructure for

Spatial Information' as collections of metadata, spatial data sets and spatial data services interconnected by network services and technologies; incorporates by agreements on sharing, access and use; and involve coordination and monitoring mechanisms, processes and procedures (EC, 2007).

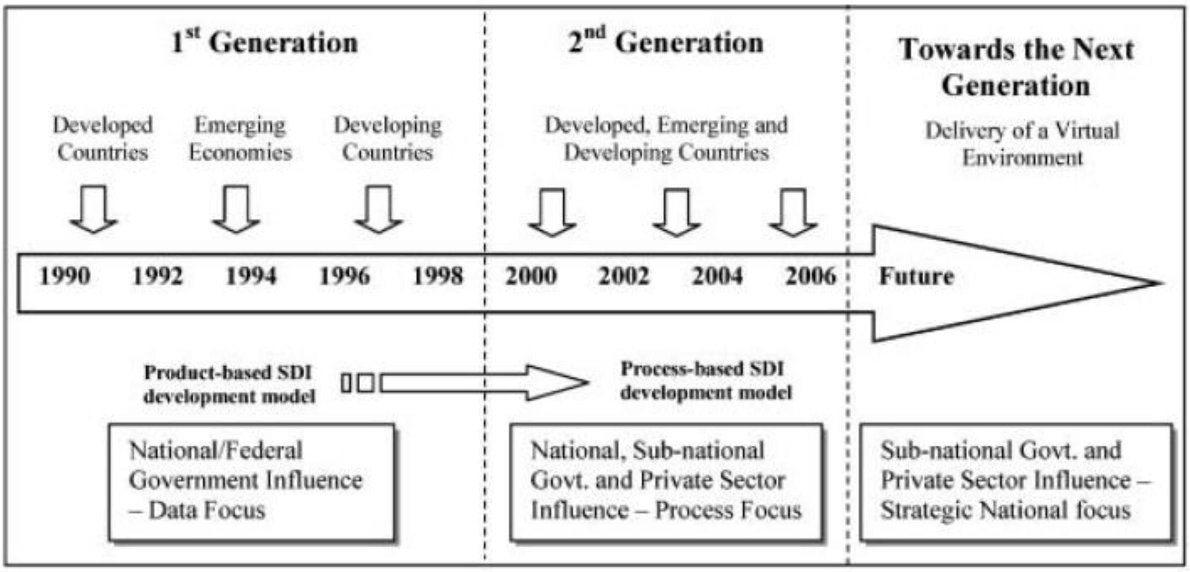


Figure 2-2: Continuum of SDI Development (Adapted from Rajabifard et al., 2006)

From the beginning of its concept in early 1990's, SDI has evolved into three different generations as presented in Figure 2-2. SDI First generation was originated by National SDI initiatives with the aim to promote economic development and stimulate better government by improving access and availability of spatial data. Characteristic of this phase is identified by the creation of large databases together with establishment of clearinghouses as the general product. The second generation was initialized in 2000 and focused more on providing service to facilitate data utilization. The process-based model is driven more by data sharing and re-using data collected by a wide range of agencies for a great diversity of purposes. Geoportal, as the gateway to spatial resources where metadata and web services lies in, was emerging in this process-based SDI. The most recent SDI generation is based on user involvement and focus one real use of spatial resources. The main principle behind this approach is to capture the users' requirements. According to Rajabifard (2006) this next generation emerge because *"there is a need for a service oriented infrastructure on which citizens and organizations can rely for the provision of required services"*. This goes ahead of the first- and second-generation SDIs which focused on data discovery and retrieval.

2.4. Spatial Data Infrastructure Development Trajectories

SDI developments range from local to state/provincial, national, and international regional levels, to a global level (Groot and McLaughin, 2000; Masser, 2005). Most SDIs were initiated by national mapping agencies (Crompvoets et al., 2004), which mean dealing with large volumes of data in national scales. However bottom-up approaches of SDI development to accommodate the richness of local GIS applications are also recognized (Yan, 2005; Nedovic-Budic et al., 2004; Muller and von St. Vith, 2009). The following table presents classification of previous SDIs development based on a number of criteria. Firstly to identify SDI development at different hierarchy level, a dichotomous comparison of top-down development (trough national committees/policies) versus bottom-up development (through sub-national governments/voluntary cooperation) was determined. Another criterion to understand the current SDI progress is comparing development around portal concept versus development around ontology concept.

Table 2-1: Example of SDI development trajectories

Criteria	Selected studies and quotes
Top-down approach	O'Donnell and Birnbaum (2005) identifies numerous bottlenecks in the implementation of Irish Spatial Data Infrastructure. These bottlenecks include: *"accessibility (identification of data providers and data types, cost, ownership constraints, and confidentiality); quality (metadata) and time (duplication of effort e.g. by 2 government departments)."* de Montalvo (2001) notes that *"a successful strategy for implementing the various components of SDI involves dynamic consideration of the appropriate options. Not only technical skills and capabilities are required but also many social skills and activities."*
Bottom-up approach	Muller and von St. Vith (2009) summarizes that *"SDI implementation at the local level closely related to and is able to fulfill many basic needs of citizens and public administration by providing huge amounts of basic spatial data. Consideration of standards, mainly those defined by OGC makes it possible to integrate local SDI bricks smoothly into an overall SDI."* Davis and Fonseca (2006) provides recommendations for implementing local SDIs *"which divided into three categories: applications, cooperation and people."* Turkstra et al. (2003) suggest that local SDI *"is not a product but an incremental development process that will progress only in case such a process is simple, cost effective, user-friendly, and flexible with clear products."*
Development around portal concept	Maguire and Longley (2005) notes that *"geoportals and SDI have made a major contribution to simplifying access to geographic information, and in so doing have helped to encourage and assist people who want to use geographic information concepts, databases, techniques and models in their work."* Crompvoets et al. (2005) reveals that *"geoportals of the developed world have positive impacts on society. The impacts are mainly economic in nature including increased consumption of spatial data and services which is the consequence of the more efficient access of spatial data and the higher distribution of spatial data by suppliers."*

Table 2-1: ***(continued)***

Criteria	Selected studies and quotes
Development around ontology concept	Georgiadou (2006) suggests *"alternative understandings of SDI concepts (information, decision processes, people, management systems, social structure and information technology) that lead to a 'cultivation' perspective for SDI design and implementation. A 'cultivation' perspective is more likely to help us understand how human actors strike and sustain a dynamic balance between global uniformity and local contextual solutions in SDI design and implementation, especially in developing regions."* Grus et al. (2007) note that *"the dynamic natures of SDI are reflected in the intensive flow of information between data producers and users, and also changes in SDI technology, people and their needs. Another aspect of the dynamic nature of SDI dynamism is its evolving nature."*

In the context of disaster management, previous studies found SDI can be implemented to reduce time wasted in data collection and to make more efficient data integration for the purpose of improving the decision making process in flood management (O'Donnell and Birnbaum, 2005), earthquake response (Mansourian et al. 2006), hazard characterizations and vulnerability assessment (Asante et al., 2006). Utilization of 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).

2.5. Spatial Data Infrastructure Technical Issues

Distributed GIS

The term distributed GIS refers to an architecture that uses the Internet or a wireless network as a primary means of providing access to deliver spatial data resources and to perform GIS analysis. Distributed GIS relies on web technologies to provide interactivity between the user and the provider. It can be accessible across platform and not limited to one kind of operating system. Generally, there are four components of distributed GIS: web client, web server and application server, map server and data server (Peng and Tsou, 2003).

Interoperability

The ability of a system to communicate, transfer data and work together with other systems is defined as interoperability. It provides information sharing and inter-application co-operative process control through mutual understanding of a request and response mechanism (Groot and McLaughlin, 2000). Two information systems can be considered having interoperability if they are able to access functions and transfer data seamlessly. Interoperability is increasingly becoming a focus point for organizations that distribute and share data over the Internet.

Geospatial Web Service

Geospatial web services are web services that allow others to access data and maps hosted by another group using interoperable technology. The specifications for serving these services are defined by The Open Geospatial Consortium (OGC) who focuses on the development of publicly available geospatial web standards. The availability of numerous OGC specifications allowing users to publish their data services in an interoperable manner.

OGC Web Services (OWS) represent a standards-based framework that enables seamless integration of various online geoprocessing and location services. By the means of internet, OWS allows distributed geoprocessing systems to communicate with each other. OWS provide a vendor-neutral, interoperable framework for web-based discovery, access, integration, analysis, exploitation and visualization of multiple online geodata sources and geoprocessing capabilities as described on Figure 2-3 (Doyle and Reed, 2001).

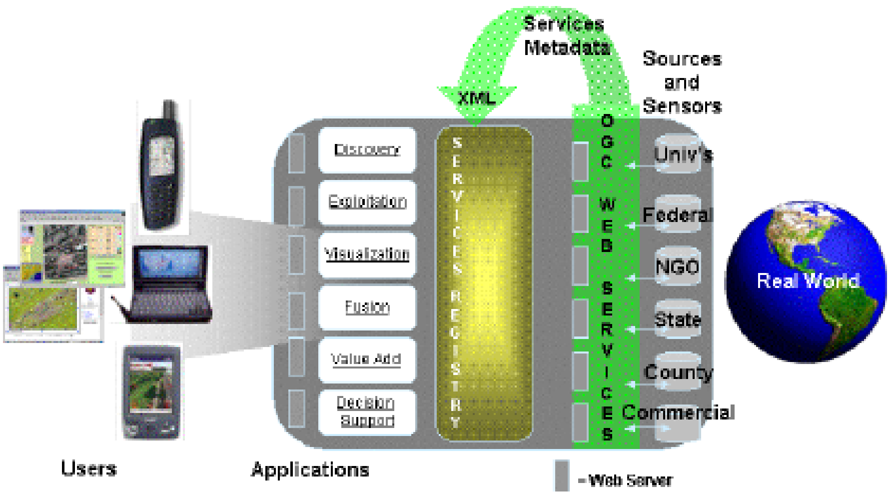


Figure 2-3: OWS functionality (Adapted from Doyle and Reed, 2001)

There are several types of web services defined by OGC, including: data services, portrayal services, processing service, and registry services. Some generally used OWS are Web Map Service (WMS), Web Coverage Service (WCS), Web Feature Service (WFS) and Web Processing Service (WPS). WCS and WFS are two instances of data services type while WMS is an example of the portrayal service type. WMS Services are more commonly used to serve maps and map layers, and perform basic queries about these layers. A WMS allows for use of data from several different servers, and enables for the creation of a network of Map Servers from which clients can build customized maps.

WFS allows for data features (as GML) to be accessed directly. WCS allows clients to access part of identified grid coverage offered by a server.

Geoportal

One of the key elements of SDI is geoportal, also known as geospatial portal. It provides access to spatial contents together with the metadata, so user can easily find spatial data that they need. The contents include offline data and OGC web services such as WMS, WFS, and WCS. One of the key features of geoportal is the ability to support data exchange and sharing between institutions via the internet. Therefore redundant data acquisition can be prevented and coordination of efforts in collecting data can be enhanced.

According to OGC (2004), there are four basic services offered by geoportal i.e. portal, catalog, portrayal, and data services. Portal services provide management and administration of the portal whilst catalog services support the ability to publish and search metadata. Portrayal services provide specialized capabilities supporting visualization of spatial information and present it to the user. Access to collections of data content in repositories and databases is provided by data services. These four services of geoportal are briefly described in Figure 2-4.

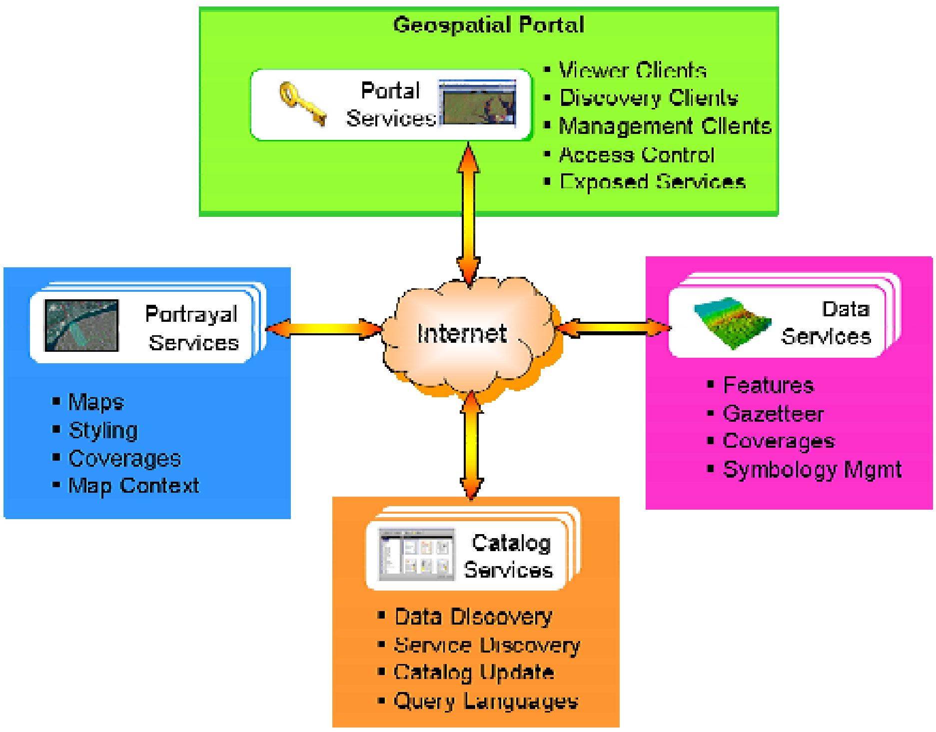


Figure 2-4: Geoportal reference architecture service distribution (Adapted from OGC, 2004)

There are two significant breakthroughs differentiate the geoportal from the clearinghouse which is the earlier spatial data discovery technology (Maguire and Longley, 2005). First, geoportal provide access of both metadata records describing services and the actual services (mapping, data download, geocoding, routing, etc.) themselves. Secondly, services can be accessed from both conventional desktop GIS applications, as well as a thin client browser.

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. Geocollaborative portal enables a single user to interact 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 of creating annotations of geospatial features in the maps (Aditya and Kraak, 2009).

Unified Modeling Language

The Unified Modeling Language (UML) refers to a standard language for specifying, visualizing, constructing, and documenting the objects of software systems, as well as for business modeling and other non-software systems. UML offers a standard way to write a system's blueprints, including conceptual components such as actors, business processes, system's components and activities. The ICA Commission on Spatial Data Standards proposes using UML for describing systematically all aspects of SDIs. UML provides a starting point for a systematic approach to analyze SDIs (Cooper et al., 2003).

UML has various diagrams that can be used to visualize the static, dynamic and behavioural aspects of a system (Tsang et al., 2005). These diagrams are briefly described as follows:

a. Use case diagram. The use case diagram captures the requirements of the system being developed. It describes a sequence of actions a system performs to yield an observable result or value to a particular actor. In other words, use cases are abstractions of dialog between the actors and the system.
b. Class diagram. The class diagram is used to describe the types of objects and their relationships by providing a static and structural view of a system in terms of its classes and relationships. A class diagram illustrates the potential links from one object to other objects.
c. Interaction diagram. The interaction diagram can be classified into sequence diagram and collaboration diagram. Both diagrams are used to describe the internal behaviours of the system and how the objects collaborate to realize the execution of a use case. The sequence diagram focuses on the temporal order of operations of objects, while the collaboration diagram focuses on static relationship.
d. Activity diagram. The activity diagram is used to model workflow. It is specifically designed for modeling performance of actions of an activity or procedure.

e. State diagram. The state diagram is a common technique to describe the dynamic behaviour of a system. It describes all the possible states that a particular object can get into and how the object's state changes as a result of events that affect the object.
f. Package diagram. A package contains UML diagrams and may contain other packages. A package diagram describes the relationships between different packages.
g. Deployment diagram. The deployment diagram is used to describe the runtime mapping of software components to the hardware resources.

2.6. Indonesian Spatial Data Infrastructure

Indonesia has enormous collection of spatial data consisting of geodetic control points, topographic database, bathymetric database, and thematic database covering most of the national territory. Such data is collected and managed by many government agencies at all levels: national, provincial, municipal and regency. Understanding the importance of public access to this data, several activities related to improvement of spatial data infrastructure was carried out through national initiative under the leadership of Bakosurtanal.

The development of Indonesian SDI was formally started in the National Coordination Meeting on Survey and Mapping in 2000. In that meeting purpose of Indonesian SDI, which is to make fundamental spatial data within the Indonesian territory available and accessible to the users, was declared. The meeting also recommends that the development of Indonesian SDI should be based on five main aspects: regulation, institutional arrangements, data, technology and human resources (Bakosurtanal, 2008). Since that meeting efforts and activities regarding improvement of Indonesian SDI has been conducted.

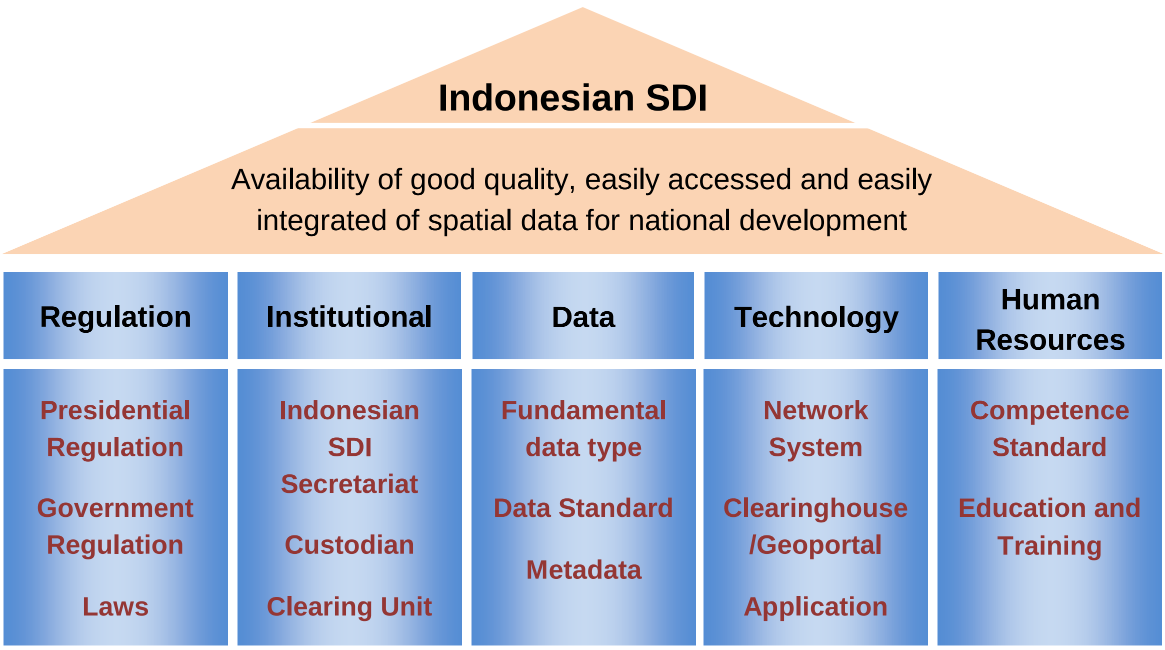


Figure 2-5: Components of Indonesian SDI (Bakosurtanal, 2008)

In the aspect of regulation, Presidential Act No. 85 was established in 2007 concerning national spatial data network. Its intention is to authorize implementation of Indonesian SDI. According to the act, national spatial data network consists of network nodes and network node connector which are interconnected through electronic based information infrastructure. The network nodes included state government institutions, provincial governments, and regency/municipality governments. Up to now declaration of the act has been implemented by state government institutions through stipulation of institutional regulation concerning their network node. Another effort that can be considered as supporting tool for regulation is publication of the guideline for Indonesian SDI on 2008. This guideline describes about the purpose, background, concept, and strategy of the development of Indonesian SDI.

Institutional arrangement efforts focus on establishment of a clearing unit in each network nodes and determination of spatial data custodianship. The clearing unit will be responsible in spatial data dissemination and exchange between network nodes. Until now several state agencies such as Bakosurtanal, Department of Public Works, and Department of Agriculture have legally identified their clearing unit. However, more effort to encourage institutional arrangement in local governments is needed because they are also part of the national spatial data network. Meanwhile, guideline of custodianship of Indonesian SDI is still in working progress. The principle of custodianship assigns to an agency certain rights and responsibilities for the collection of spatial information and the management of this on behalf of the community.

Actions in the aspect of data improvement include provision of spatial data based on the Presidential Act No.85/2007, development of metadata for every spatial data and development of data standards. Standard for metadata was adopted from Federal Geographic Data Committee (FGDC) known as "*Content Standard for Digital Geospatial Metadata"*. There are 14 national standards regarding spatial data were established since the year 2000 (Bakosurtanal, 2007). One thing still need to be enhanced is the integration of spatial data possessed by various different institutions. In order to achieve integrated spatial data, a standard of feature catalog is required. Up to now Bakosurtanal is still developing a national feature catalog that can be used by local and national institutions.

Related to technological aspect, Bakosurtanal has been developed a clearinghouse since 2002 which provides information about spatial data existed in Indonesia (Puntodewo and Nataprawira, 2007). The clearinghouse consists of metadata servers from data provider and interconnected within a network. The clearinghouse can be accessed through Indonesian SDI website (www.idsn.or.id) which also provides information about recent activities and efforts. Additionally, a national geoportal which provide spatial services and information of available data is in developing state and targeted to be functional in 2013 (Technology Indonesia, 2008).

In the development of human resources, Bakosurtanal has the mandate to increase knowledge and capability of the manpower regarding SDI at local, provincial and national institutions. Actions to create and improve SDI awareness have been established, such as workshops, socialization and training. National coordination meeting among Indonesian SDI stakeholders is annually held since 2000 (Puntodewo and Nataprawira, 2007). Bakosurtanal has been providing formal training about utilization of GIS technology, survey and mapping technique, and metadata creation. Nevertheless, many efforts on capacity building to the national and local government institutions are still required.

This study focuses on developing an application of a local SDI in the context of disaster risk management. It identifies the existence of spatial data utilization at local government agencies including the problems, requisites and important issues. Results of this study can be used as best practice of the implementation of an SDI at the local level. Moreover, the technical side developed in this research can provide significant contribution for a national SDI implementation.

3. METHODOLOGY

This chapter explains about method of the research being conducted. It is divided into three stages, pre-fieldwork, fieldwork and post-fieldwork activities.

3.1. Fieldwork Preparation

Activity before fieldwork was initiated by literature search (report, product, journals, and newspaper) to gather knowledge about management of Merapi Volcano disaster. As this study is exploring the potential use of a local SDI in supporting Merapi volcanic risk management, identification and data requirements of local SDI should be clarified to build basis for developing the application. From the literature findings the author constructed interview questions and formulated the questionnaires. Besides that to determine which institutions selected as the respondent is based on result in the literature review.

Interview was arranged to two local government institutions at Sleman Regency, Dinas P3BA which is determined as the key player of disaster management and Bappeda which is assumed as the significant party of local SDI. Questions of the interview were structured to guide information extraction from those institutions (see Appendix 1). The questionnaires were composed into four sections (see Appendix 2) in order to collect all the information needed. First section is about profile of the respondent including name, name of institutions, job position, and email address. Second section is focused on spatial data availability in each institution while section three concerned with spatial data access and sharing. The last section is about spatial data requirement of evacuation planning of Merapi Volcano disaster.

3.2. Fieldwork

Fieldwork of this study was started from 28 July until 3 September 2009. There were three main activities of the fieldwork. First was primary data collection by interviewing two local government institutions to gather information about risk management activities of Merapi Volcano and existence of local SDI. Another primary data collection through a questionnaire survey to 15 selected institutions was the second activity. Those two activities are supported by secondary data collection through collecting report, product and documentation from the local government institutions. Last activity was mapping the evacuation barracks and bunker in Merapi volcanic hazard zones. Since this study focused on evacuation planning, data regarding evacuation barracks and bunker is important. Fortunately Dinas P3BA only posses' tabular data regarding evacuation barracks and it has not been updated since 2006. Therefore field survey using GPS, digital camera and Topographic map of Sleman Regency was conducted. Purposes of the fieldwork together with methods and selected institutions as the respondent were presented in the following table.

Table 3-1: Fieldwork purposes and methods

No.	Purpose	Method	Locations
1.	describing the Merapi volcanic risk management activities and institutions/agencies involved, particularly in the evacuation planning	Interview	Dinas P3BA
2.	identifying the existence of local SDI at Sleman Regency	Interview	- Bappeda - Kantor Telematika
3.	a. determining spatial data availability, access and sharing in local agencies of Sleman Regency b. identifying spatial data requirements and services in the evacuation planning of Merapi volcanic hazards	questionnaire survey	- Dinas P3BA - Bappeda - BPPTK - Dinas Kimpraswilhub - Dinas Kesehatan - Kantor Telematika - Polres Sleman - Kodim 0732 - Dinas Pol PP & Tibmas - BPPD - Badan Kesbanglinmas - Bidang Tapem - UGM - UPN - NGO
4.	mapping the evacuation barracks and bunker of Merapi volcanic Disaster	field survey	- Kecamatan Cangkringan - Kecamatan Pakem - Kecamatan Turi - Kecamatan Tempel

3.2.1. Interview Process

The first interview was conducted on 28 July 2009 at Dinas P3BA. The author met Head of Natural Disaster Department, Singgih Sudibyo and Asih Kushartanti, senior staff. Open-ended questions regarding the activities of Merapi volcanic risk management was asked together with questions on evacuation planning. Second interview was carried out at Bappeda on 4 August 2009. The interviewees are Head of Planning of Technology and Cooperation Department, Triendah Yitnani and Head of Data and Information Sub-Department, Sri Subekti. Questions regarding spatial data infrastructure at Sleman Regency was briefly explained by them. Beside that they were also provide some supporting data such as reports, products and notes of meeting.

The last interview was held at Kantor Telematika on 2 September 2009. The author was accepted by Head of Electronic Data Unit, Eka Suryo. Besides explaining about the existence of spatial data infrastructure, he also describe schema of computer networks in local government institutions of Sleman Regency. All of the interview process was recorded using voice recorder. Results of this stage will be used in the analysis of Merapi volcanic risk management activities and local SDI at Sleman Regency.

Figure 3-1: Interview activities

3.2.2. Field survey

In this activity the author was carried out inventory of evacuation barracks and bunker for protection against Merapi eruptions. Before started the survey, preliminary data was obtained from Dinas P3BA as well as topographic map of Sleman Regency from Bakosurtanal. Location of evacuation barracks was plotted by GPS and its condition was recorded. The inventory includes observation of facilities in the barrack such as electricity, toilet, and water source. In addition, informal interview with the village officials was held to gather information regarding daily function of the barrack if there is no emergency situation. All of evacuation barracks and bunker was captured using digital camera.

Figure 3-2: Field survey activities

Figure 3-3: Evacuation barracks and bunker

3.3. Data Analysis

After results from the respondent was collected, there is data validation process before data analysis conducted. Some of the answers from questionnaires survey need to be verified by comparing it with 'hard evidence' such as reports and documentation. Another way to validate the opinion was by visual observation to the respondent. For example in order to check whether local institutions used GIS in their work, the author asked the respondent to show these GIS. This confirmation process will make the questionnaire results more valid and reduce subjectivity of personal opinion.

The next step was data analysis. Questionnaire results were stored in database using *Microsoft Excel*. The database contains answers from 22 respondents which come from different institutions. For dichotomous type questions the answer was presented in percentage as well as multiple choice questions. In the meantime result of open questions was typed into database same as what the respondent wrote on the questionnaire form. Information collected from interview and questionnaire survey was then analyzed to describe and explain the Merapi Volcano risk management efforts and identification of local SDI at Sleman Regency. The analysis is presented in chapter four and chapter five.

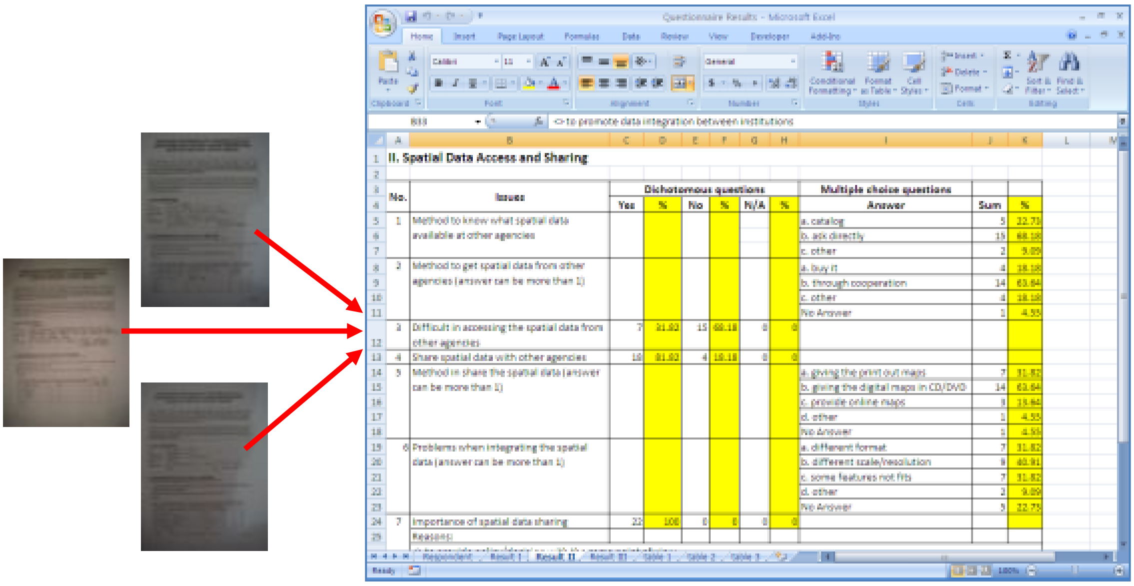


Figure 3-4: Questionnaire results stored in Excel file

Data collected from field survey was also stored in *Excel* file. Afterwards all of location points and its attributes were processed using *ArcGIS* in order to produce map of location of evacuation barracks and bunker available at Kecamatan Pakem, Cangkringan, Turi and Tempel. This information will be used as one of the data theme required by the application.

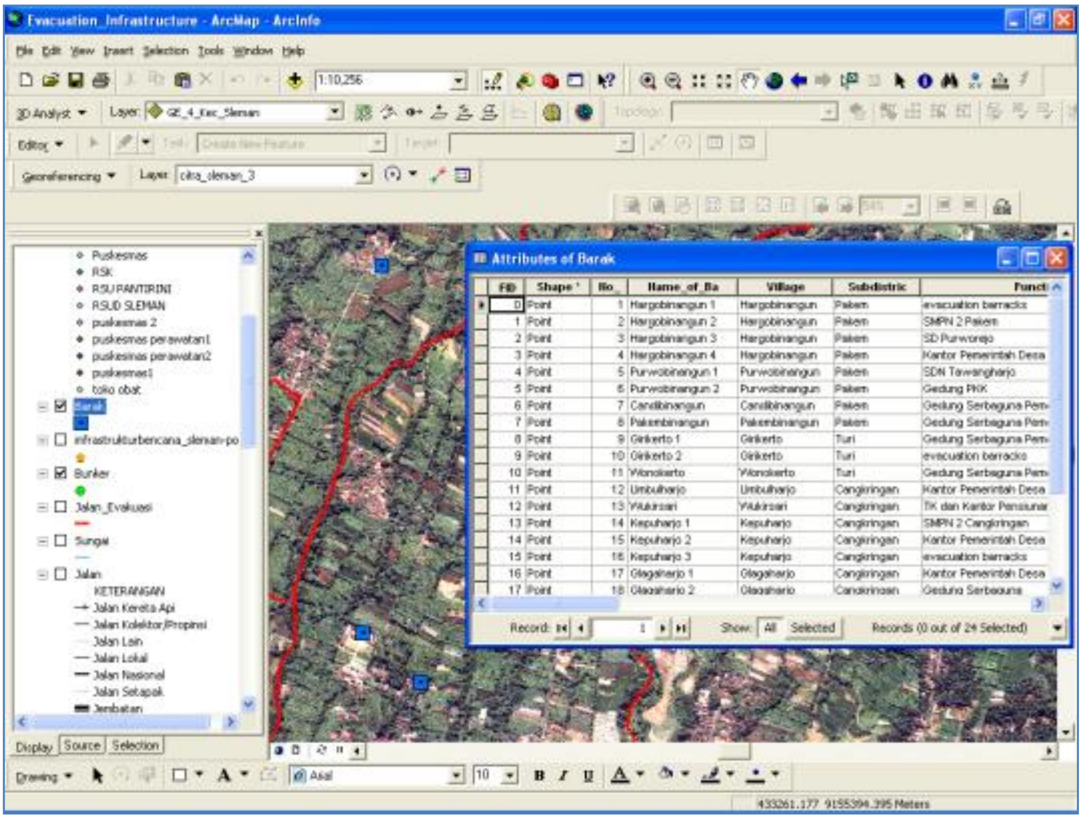


Figure 3-5: Field survey results processed in *ArcGIS*

3.4. Design Process

Requirements of the user regarding spatial data infrastructure for evacuation planning were translated into design of the application. Results from questionnaire and secondary data collection were identified. After that UML diagrams were utilized to design the application based on these findings.

The author uses *Visual Paradigm for UML (VP-UML)* Community Edition in creating UML diagrams for the application. *VP-UML* supports all UML diagrams and offers numerous useful features to help user to develop software system throughout the complete software development life cycle. Its latest version is version 7 and can be downloaded at the website www.visual-paradigm.com. The interface of *VP-UML* can be seen in the following figure.

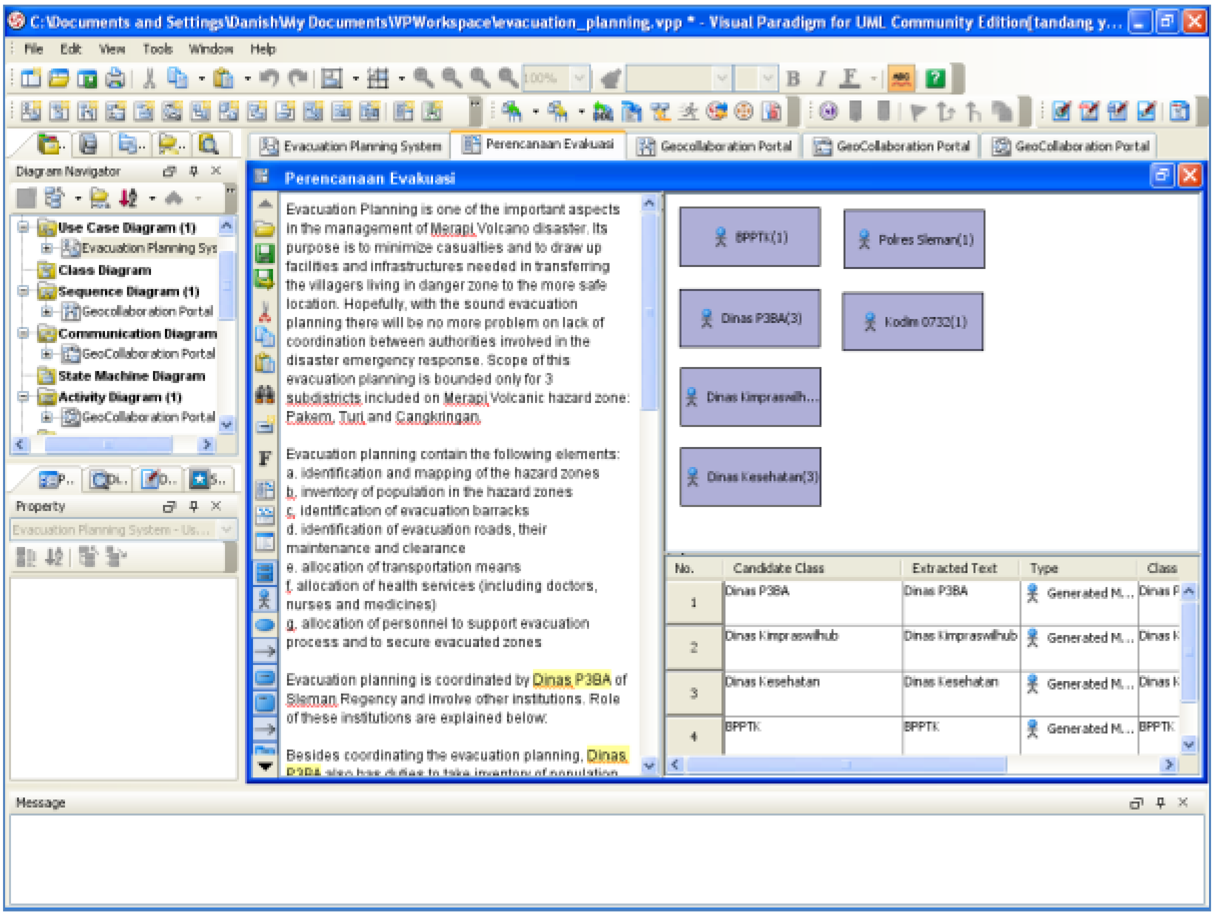


Figure 3-6: *VP-UML* environment

3.5. Development of The Prototype

There are two phases in development of the prototype. Firstly the author was created geospatial web services that required for evacuation planning. By means of WMS, spatial data resource in different format such as *shapefile ArcGIS* or MapInfo file will be presented as map layers in image/raster format. The author also was making used Keyhole Markup Language (KML), which is an XML-based language schema for displaying geographic data in an earth browser, such as *Google Earth*, Google Maps, and Google Maps for mobile.

Secondly the author utilizes GeoCollaboration Portal (Aditya, 2008) – an application of a local SDI developed by Dr. Trias Aditya, for implementation of the prototype. The GeoCollaboration Portal aims to support decision makers investigate, analyze and provide alternative solutions when dealing with disaster management at Yogyakarta Province. It facilitates data sharing through availability of enhanced map interface where various WMS layers can be cascaded synchronously. Beside that 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 Application Programming Interface (API)*. It is also equipped with HTML and JavaScript in the client side, therefore user can send request and receive response through the internet browser. Customization of the portal for this research is explained further in Chapter 6.

3.6. Evaluation method

In order to evaluate the prototype, the author conducts user group assessment which is one type of usability testing. According to Rubin and Chisnell (2008), usability testing refers to a process that occupies people as testing participants to evaluate the product whether it meets specific usability criteria. The assessment test is probably the most typical type of usability test conducted. It is usually held after the design process of the prototype has been established.

Components of usability criteria are include usefulness, effectiveness, satisfaction and accessibility (Rubin and Chisnell, 2008). Usefulness related with the degree to which a product enables users to achieve their goals. Effectiveness refers to the degree to which an interface facilitates a user in accomplishing the task for which it was intended. It is usually measured quantitatively with error rate and tied to some percentage of total users. Satisfaction refers to the user's perceptions, feelings, and opinions about the prototype. Accessibility is a general term used to describe the degree to which a product is accessible to the users. The user group assessment measured the prototype based on these usability aspects.

4. MERAPI VOLCANIC RISK MANAGEMENT AT SLEMAN REGENCY

The first section of this chapter discusses about activities of Merapi volcanic risk management conducted by the Sleman Regency government. Section two explains which institutions involved together with their role. The next section describes what spatial data are needed in the risk management activities. Evacuation planning as the study case for local SDI implementation is explained in the last section.

4.1. Activities of Merapi Volcanic Risk Management

The fact that Sleman Regency is one of the closest regions to Merapi volcanic hazards has raise awareness of the local government to develop risk management. Activities of Merapi volcanic risk management at Sleman Regency can be classified based on disaster management phases as stated in Smith et.al. (2009), which are risk assessment, mitigation, and preparedness. These activities are explained in the following sections.

4.1.1. Risk Assessment

Activity of mapping the hazards of Merapi Volcano essentially was conducted by VSI as the authorities on monitoring and analyzing Merapi Volcano movement. VSI 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 with scale 1:50,000. The base map was derived from topographic map (1:25,000) which produced by Bakosurtanal. The hazards map was compiled based on geomorphology, geology, eruption history, distribution of previous eruption products, field study and it detailed the types of volcanic hazards which cover Central Java and Yogyakarta Special Province.

According to the map, there are three levels of hazard zones as follows:

- Hazard Zone 1

  The first level of hazard zone is potentially affected by lahars and flood. During the eruption increases, these areas are susceptible to volcanic ash fall and ejected rock fragments. Most of the areas are located along and near the river valley originating from the summit area. These rivers valley include Apu, Trising, Senowo, Pabelan, Lamat, Blongkeng, Putih, Batang, Krasak, Boyong, Kuning, Gendol, and Woro River.

- Hazard Zone 2

  The second level of hazard zones is distinguished into two groups. First group incorporates areas affected by mass flows such as pyroclastic flows, lava flows and lahars. Another group includes areas potentially influenced by ejected materials such as thick dry volcanic ash, volcanic bombs and other ejected rocks. The farthest distribution of pyroclastic flows is 13 km away from the eruption center while lava flows might reach farther down to 900 m elevation as happened in the latest 18th century. The boundary of ejected material is based on tephra deposits at a distance of 6 – 10 km from the eruption center.

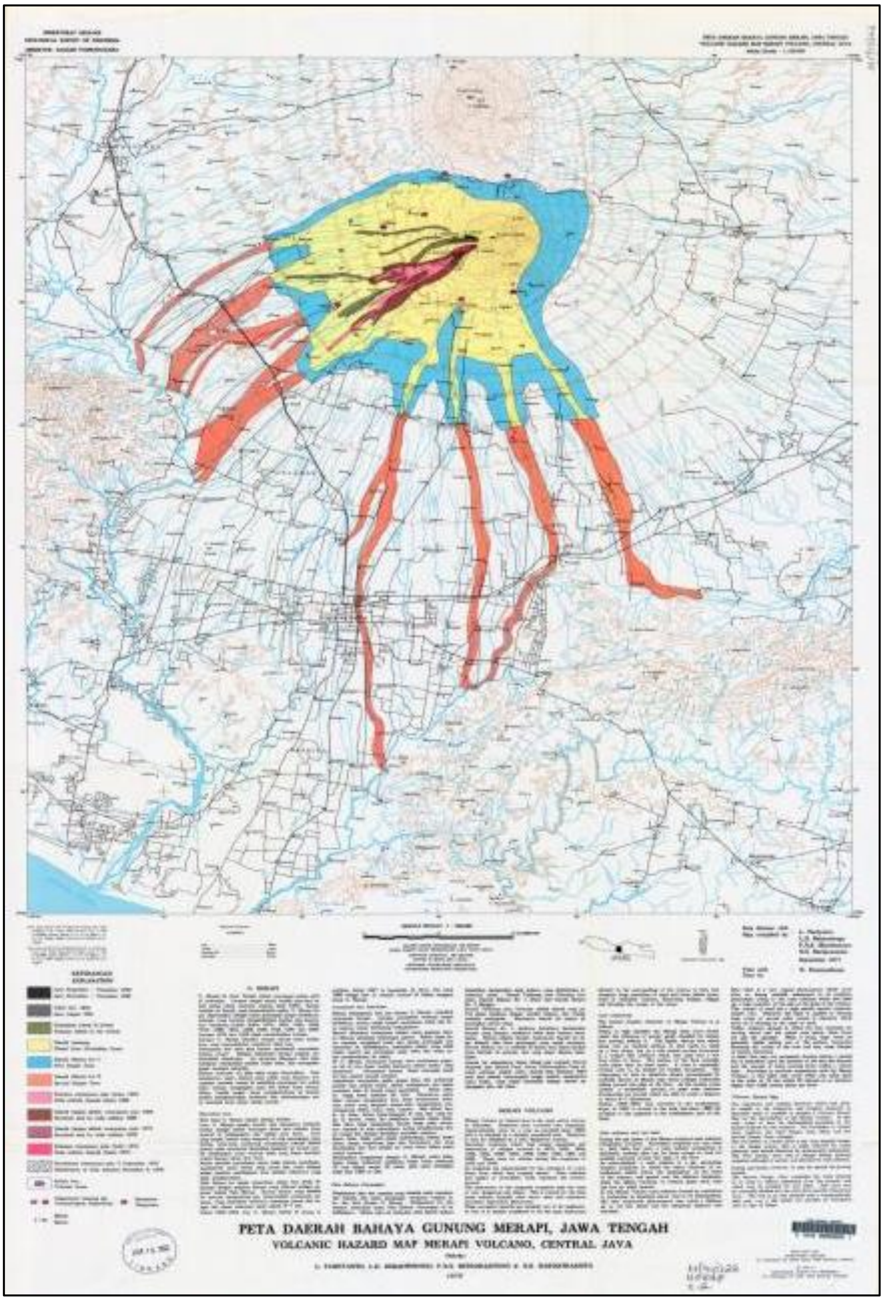


Figure 4-1: Volcanic hazard map of Merapi Volcano

- Hazard Zone 3

  These areas are located near the hazard source and frequently affected by pyroclastic flows, lava flows, rock falls, toxic gasses and glowing ejected rock fragments. The boundary of hazard zone 3 is based on activity history within a hundred years since 1900, small volume dome-collapse with limited reach (3-7 km from the summit), morphological changes around the summit area, geologic structure of the summit, and dome condition of present activity.

Local government of Sleman Regency make use the hazard map to identify villages and sub-villages prone to volcanic disaster and employ this as a basis to compile the risk map. Information on hazard area is used to determine location of evacuation barracks or to select which village appropriate for socialization activities. In addition to that, the local government has established risk map of Merapi Volcano in 2004 with a support from Gadjah Mada University. The risk map is compiled from hazard information, population distribution, land utilization and rainfall data, and applied scoring method to determine risk criteria. By means of overlay GIS technique, the results identify several villages which have the highest risk i.e. *Desa* Umbulharjo in *Kecamatan* Cangkringan, *Desa* Purwobinangun in *Kecamatan* Pakem and *Desa* Wonokerto in *Kecamatan* Turi (Dinas P3BA, 2004).

4.1.2. Mitigation

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.

In terms of constructing bunkers for mitigation, the local government was supported by the national government, in this respect Departement of Housing and Infrastructure (now Department of Public Works). There are two bunkers around Merapi Volcano within Sleman Regency; first bunker is located at *Dusun* Tunggularum, *Desa* Wonokerto, *Kecamatan* Turi and the second one at *Dusun* Kaliadem, *Desa* Kepuharjo, *Kecamatan* Cangkringan. These bunkers were designed to provide temporary protection from hot clouds and rock falls.

Evacuation barracks were built as temporary place for the inhabitants to take cover from the danger of Merapi Volcano. According to the field survey results, in overall there are 24 evacuation barracks located at *Kecamatan* Tempel, Turi, Pakem and Cangkringan. Some of the barracks have daily function as village office whereas others were used as school or multifunctional building (see Appendix 3). Meanwhile, identification of evacuation roads has been conducted since 2004 by the local government. Most of the local roads at the sub-districts were utilized as the way to evacuate people to a safer location. Total length of the evacuation roads is approximately 117.3 km (Dinas

P3BA, 2009). Location of the bunkers, evacuation barracks and evacuation roads at *Kecamatan* Tempel, Turi, Pakem and Cangkringan is presented in the figure below.

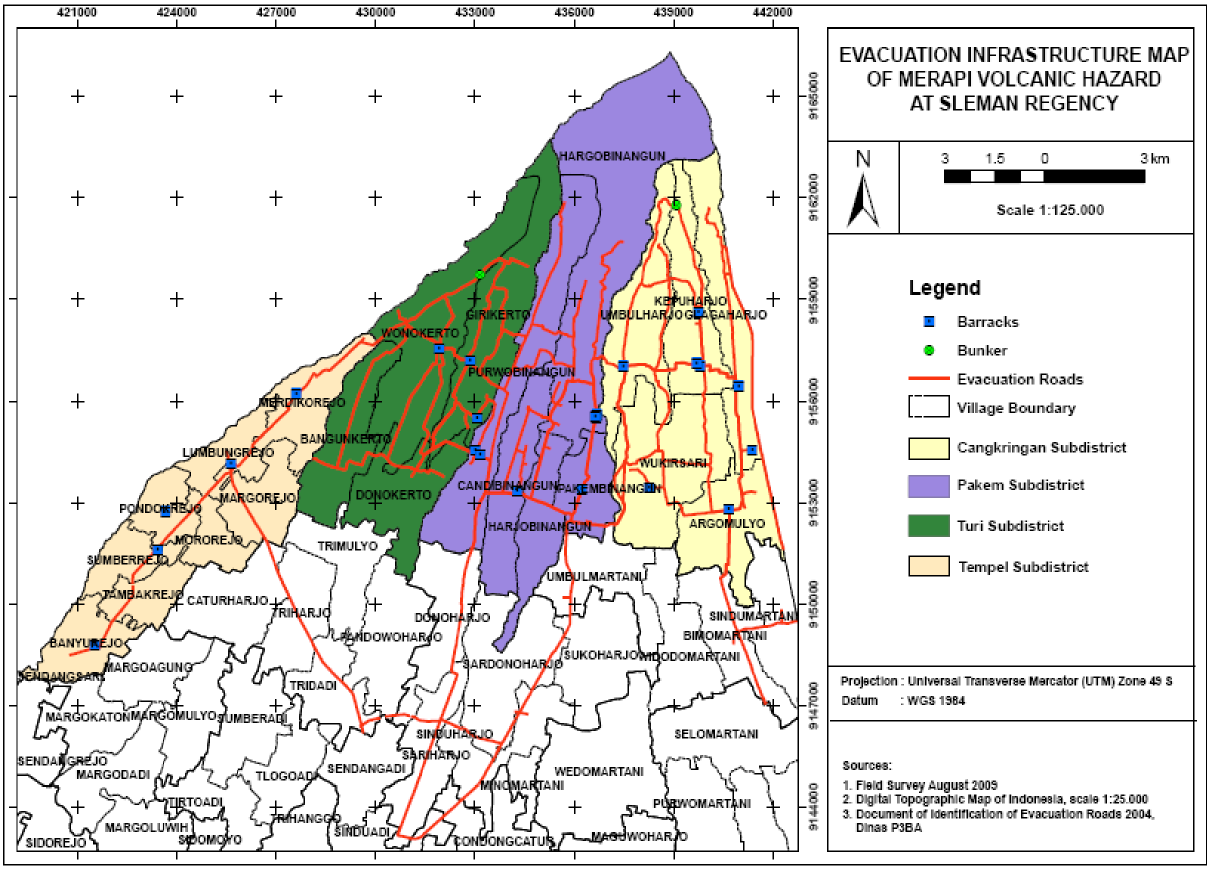


Figure 4-2: Location of infrastructure for evacuation process at Sleman Regency

Another important structural mitigation effort is development of the EWS around Merapi Volcano. The EWS is distinguished based on the hazard types, specifically EWS for pyroclastic flows and EWS for lahars flows. EWS for pyroclastic flows aimed to alert people concerning existence of the dangerous flow and it consist of sirens which are located at five sub-villages: Kaliurang Timur, Kaliurang Barat, Gumuk Bol, Kinahrejo, and Kalitengah Kidul. System of instrumentation also constructed to detect and monitor the lahars around the stream of Merapi Volcano, especially within Krasak, Gendol, and Boyong River. There are two rainfall sensors installed at Gendol River, one in Klangon and another in Petit Opak. The local government also installed one sensor in Turgo, near the Boyong River. Meanwhile seven sirens unit were developed to warn the community about the lahars flood. They are located at Kaliadem, Manggong, Bronggang, Jambon, Turgo, Kalireso and Kemiri. In addition to modern instruments of the EWS, the local community applied traditional equipment which is called 'Kentongan' to warn about the incoming danger. Example of the EWS is presented in the following figure.

Figure 4-3: EWS of Merapi Volcano (Dinas P3BA, 2007)

The local government had produced several regulations as one of the non-structural mitigation efforts. These rules which intended to set up the management of Merapi Volcano disaster are as follow:

1) Bupati Act of Sleman Regency No. 83/Kep.KDH/A/2006 about mechanism of disaster management of Merapi Volcano;
2) Bupati Act of Sleman Regency No. 85/Kep.KDH/A/2006 about operational plan of disaster management of Merapi Volcano; and
3) Bupati Regulation of Sleman Regency No. 7/Per.Bup/2006 about executing unit of disaster management.

The Bupati Act No. 83 arranges the activities that should be established before, during and after the disaster, including the standard operating procedure for emergency response, equipments that should be prepared, and procedure for managing the aids. A detailed operational plan for *Kecamatan* Turi, Pakem and Cangkringan was described in the Bupati Act No. 85, together with information of the supporting institutions and personnel. Additionally, the local government also produced a contingency plan as a guideline in preparing disaster response and as a basis for mobilizing available resources. The plan which developed in 2009 contains policies and strategies of the local government to achieve effective disaster management of Merapi Volcano. It includes planning of the managerial, infrastructures and facilities, health, and logistics sectors. Moreover inventory of required resources based on specific hazard scenario was also explained.

4.1.3. Preparedness

Preparedness efforts related with raising public awareness regarding the risk of Merapi Volcano. The local government used socialization as one of the method to give understanding to the community about Merapi volcanic hazards and to inform how they should anticipate and prepare for the disaster.

The socialization is conducted 20 times within a year and held at villages in the hazard zones (Dinas P3BA, 2009). Another method is by performing evacuation drill which involves the community, local government agencies, NGOs and volunteers. It aimed to make people lived in the danger area conditioned with the emergency situation so they will be ready to anticipate the danger. The latest evacuation drill was conducted on 20 January 2009 at *Dusun* Tunggularum.

Besides increasing community awareness, the local government also provide education for the Search and Rescue (SAR) Team. In 2006 there were 60 people from youth organizations trained about the basic search and rescue methods including basic of first aid, compass and map reading, and surviving procedure. With this training, the skill and expertise of the SAR Team is expected to be enhanced thus they will able to perform search and rescue operations specifically in rugged and mountainous terrain.

One more essential effort regarding preparedness is formulation of the Community Emergency Response (CER). It is intended to activate community participation in order to develop proper response during emergency situation. There are a number of associate communities existed in Merapi Volcano area, for instance *Paguyuban Sabuk Gunung (Pasag) Merapi, Radio Komunitas Merapi, and Paguyuban Saluran Komunikasi Sosial Bersama (SKSB).* All of them included in the CER and have considerable functions in monitoring and communicating recent condition at the Merapi Volcano area by using means such as Handy Talkie or radio community.

4.2. Institutional Arrangements of Merapi Volcanic Risk Management

According to the Bupati Act of Sleman Regency No. 26/Kep.KDH/A/2003, in a structural manner Dinas P3BA is pointed as the coordinator of the disaster management activities. The department in Dinas P3BA which handles this function is Department of Natural Disaster Management. Their main duty is to organize operation and management of natural disaster at Sleman Regency. In performing the activities, other institutions are also involved. Bupati Act of Sleman Regency No. 83/Kep.KDH/A/2006 stated these institutions together with their role, as described in the table below.

Table 4-1: Role of institutions in Merapi volcanic risk management activities

No.	Institution	Role
1.	Dinas P3BA	✚ Coordinate and perform risk management activities such as formulation of the contingency plan, evacuation drill, etc. ✚ Provide central command post as a place for controlling disaster operation ✚ Prepare evacuation infrastructure such as barracks, tent, and emergency lamps ✚ Organize report and administration of disaster management

Table 4-1: ***(continued)***

No.	Institution	Role
2.	Bappeda	✚ Formulate the spatial planning based on Merapi hazard information ✚ Provide spatial data for mapping the Merapi volcanic risk
3.	BPPTK	✚ Provide volcanic hazard map of Merapi Volcano ✚ Monitor and analyze the activity of Merapi Volcano ✚ Determine alert level of activity of Merapi Volcano
4.	Dinas Kimpraswilhub	Responsible to provide transportation facilities and infrastructure for disaster management such as transportation means, evacuation roads, additional facility in evacuation barracks, and clean water
5.	Dinas Kesehatan	Responsible to provide health facilities and operational at the dangerous zone, including doctors, nurses, ambulances and medicines
6.	Dinas Nakersos & KB	✚ Support operational of public kitchen and provide logistics, including foods and clothes for the evacuee ✚ Organize the funeral for the dead victims
7.	Kantor Telematika	✚ Responsible to provide communication and information means such as Handy Talky (HT) and CCTV ✚ Prepare the early warning system
8.	Polres Sleman	✚ Responsible to secure community in emergency situation ✚ Support the evacuation process
9.	Kodim 0732 Sleman	✚ Responsible to secure community in emergency situation ✚ Support the evacuation process ✚ Distribute logistics aid
10.	Dinas Pol PP & Tibmas	✚ Provide personnel to support emergency response ✚ Participate in 24 hours posted guard ✚ Prepare fire extinguishing unit
11.	PLN	Supply electricity
12.	PDAM	Provide clean water

From the table above we can see that in performing Merapi volcanic risk management activities, Dinas P3BA need to cooperate with other institutions. For example in composing the risk map of Merapi Volcano, Dinas P3BA requires spatial data such as administrative boundary, building, and population density from Bappeda. On the other side, Bappeda also need information about Merapi volcanic hazard and the risk to the community as one of the consideration input in creating the spatial planning for Sleman Regency. Therefore area development at Sleman Regency will be more effective since it accommodate disaster aspect provided by Dinas P3BA.

There are several overlapping roles identified among institutions. For instance Polres, Kodim and Dinas Pol PP & Tibmas are having the same task to handle security and support the operational of evacuation process. This overlap might be happen since those institutions are member of the Satlak PB. Another overlapping role can be found between Dinas Kimpraswilhub and PDAM which provide clean water for the evacuees. This indicates that coordination between these agencies needs to be achieved in order to avoid ineffective clean water service.

Roles of other institutions are mainly appropriate with their own work function. For example BPPTK provides the hazard map and determine alert level based on recent observation on activity of Merapi Volcano. Another example includes Dinas Kesehatan which prepares health facilities in disaster emergency and response.

4.3. Data Required in Merapi Volcanic Risk Management

Risk management of Merapi Volcano require comprehensive information incorporates spatial and non-spatial data types. Inventory of data needed is done by studying report, literature, and also from the interview as presented in the following table.

Table 4-2: Spatial and non-spatial data needed in Merapi volcanic risk management

No.	Data theme	Elements
1.	Volcanic hazard map of Merapi Volcano	hazard zones, lava flows, lahars flows
2.	Administrative	parcels, sub-village and village name, boundary, location of village office
3.	Hydrology	river, irrigation
4.	Landuse	by type, by density
5.	Transportation	road networks, evacuation roads, public transport
6.	Environment	slope, soil types, rainfall
7.	Health facilities	hospitals, *Puskesmas*,doctors per village
8.	Population/Demography	totals, household numbers, by gender, by village and sub-village, potentially affected
9.	Built environment	houses, buildings, schools, evacuation barracks, bunker, police station
10.	Utilities	water, electricity, telephone
11.	Economics	employment, unemployment, poverty, household income

Risk management requires various data that are provided by many sources. Those sources of primary and secondary data include local agencies, provincial agencies, national agencies, and other public bodies. The risk management uses data which represented in scales ranging from large (e.g., 1:5,000) to small (e.g., 1: 50,000) and in different format (e.g. tabular data, images, sketch maps, or digital maps). This often causes problems when integrating the data. For example, the hazards map provided by BPPTK was accessible in hardcopy format with scale of 1:50,000, while it is expected to deploy the map for more detailed administrative units. Most of the spatial data required were available at local agencies such as Bappeda for administrative, hydrology, landuse, and utilities; Dinas Kesehatan for health facilities; and Dinas P3BA for evacuation infrastructure.

4.4. Evacuation Planning of Merapi Volcano Disaster

Evacuation planning is the activity to arrange the evacuation process of the villagers living in the danger zone in order to locate them to a safer location. In terms of Merapi Volcano disaster, Sleman Government includes the arrangement of evacuation in the contingency plan. Evacuation planning is organized for villages and sub-villages at *Kecamatan* Pakem, Cangkringan, and Turi 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. Apart from that, the Bupati act of Sleman Regency No. 83/Kep.KDH/A/2006 describes a standard procedure of evacuation process if Merapi Volcano starts to erupt as follows:

a) Preparation of evacuation process started when the alert level is “Siaga”. VSI has determined a system of four levels of alert in the context of Merapi Volcano as follows:
    - Alert 1 (Code Green – Active Normal – "Aktif Normal") - No activity based on monitoring visual seismicity and other events. No eruptions in foreseeable future.
    - Alert 2 (Code Yellow – Danger - "Waspada") - Increased seismicity and other volcanic events such as gases. Visual changes around the crater and magmatic, tectonic or hydrothermal disturbances. Eruption is not imminent; however, due to the increased danger, local officials should prepare for a disaster.
    - Alert 3 (Code Orange – Ready to Erupt - "Siaga") – Rapid rise in seismicity accompanied by obvious visual changes in the crater. Large eruption possible within one to two weeks, depending on data analysis.
    - Alert 4 (Code Red – Active Danger - "Awas") – Small eruptions have been identified and/or potential for a large eruption spewing ash, lava and gases. A major eruption is imminent, possibly within 24 hours.

b) On “Siaga” level early warning is activated. The inhabitants started to self-evacuate. Secure evacuation roads should be selected, for example avoid crossing the river. Self-evacuation is transference of the inhabitants to a safer area based on their own willingness. It is conducted particularly for children, pregnant women, elderly, sick and disabled people.

c) The evacuees is gathered in transit points and then transferred to evacuation barracks by means of transportations (trucks and buses). Generally transit point is selected near the evacuation roads. Transportations means and traffic control of evacuation roads are managed by Dinas Kimpraswilhub.
d) Evacuees arrived at evacuation barracks. Satlak PB instruct to start operate public kitchen to fulfill evacuees' need. Food supply, blanket, mattress are provided by Dinas Nakersos & KB as the local institution responsible for logistics. Distribution of logistics is based on quantity of evacuees in the barrack.
e) Satlak PB also instructs to provide health services for people in the barrack. Health services are coordinated by Dinas Kesehatan. It is divided into three shifts for 24 hours. In addition to that, health service also provided at *Puskesmas*, *Puskesmas Pembantu* and Mobile *Puskesmas* in each sub-district. Dinas kesehatan also prepare medicines, medical equipment and ambulance.
f) On "Awas" level, Satlak PB order to conduct total evacuation for all inhabitants in hazard zones. They must be displaced to evacuation barracks and area in the hazard zones must be cleared. On this alert level access to hazard zones is closed in order to secure property and safety of the inhabitants.

Even though the operation procedure has been formulated, in reality experience from the 2006 eruptions had revealed some common hindrances in the evacuation process. Inadequate allocation of medical services in evacuation barracks is still happened as many of the evacuees have not received gas mask to prevent from volcanic ash. Consequently, some of them were coming down with respiratory infection (Kedaulatan Rakyat, 2006). Another emerged issue was related with the condition of evacuation roads (Tupai, 2006). Immediate identification of damaged and impassable roads is essential as an input for the local authorities to perform appropriate reparation or maintenance. Moreover, there was also a problem regarding livestock of the villagers. Many of them were returned to their villages during evacuation phase because worried that their livestock and crops would be vulnerable to theft (Antara, 2006). The local government needs to determine places and strategies to relocate these cattle.

4.5. Concluding Remarks

Being aware about the potential danger of Merapi Volcano, Sleman Government has performed risk management activities to lessen the disaster impacts on community. Hazards identification, risk assessment, mitigation measures and preparedness were constructed with cooperation from national agencies, academic institutions, NGOs and community participation. The risk management efforts require provision of spatial data and partnership among local agencies.

The local government also has established a standard operating procedure for evacuation process which determined as one of the essential aspects of emergency management. Nevertheless implementation in the field was quite different. Insufficient medical services, identification of damaged evacuation roads and livestock dilemma of the villagers are some examples of difficulties occurred in 2006 eruptions. Optimization of spatial data and its technology to support collaboration among local agencies is needed in order to overcome such problems.

5. LOCAL SPATIAL DATA INFRASTRUCTURE AT SLEMAN REGENCY

This chapter identifies existence of local SDI at Sleman Regency based on information collected in the fieldwork. Discussion will be based on SDI components consist of regulation, institutional arrangements, data, technology and human resources.

5.1. Regulation

At national level, regulation concerning implementation of SDI has been arranged by the Presidential Act No. 85/2007. Article 5 of the Act stated that one of the National Spatial Data Network (NSDN) elements is the local city or regency governments. Furthermore the subsequent article explained that the local governments as the network node of NSDN have responsibilities to:

a) Collect, maintain and update the spatial data;
b) Exchange and disseminate spatial data under its mandate;
c) Provide spatial data that is accessible to public pursuant to the prevailing laws and regulations;
d) Establish spatial data access system which integrated into the NSDN access system;
e) Perform coordination among spatial data stakeholders in their respective fields and submit spatial data and metadata to the respective clearing unit; and
f) Develop guidelines and technical standards of spatial data in the respective field.

This rule implies that local government will have a major role of administration, coordination, organization, and manifestation in local SDI development. It will also make a local SDI has similar structure with the national SDI. Assignment of coordinating institution at local level is required under the direction of Bakosurtanal as the network node connector. In addition, a local clearing unit is also needed to enforce the use of standards and disseminate metadata to the users.

The importance of local SDI implementation has been recognized by Sleman Government. However, the development of local SDI at Sleman Regency is still in the initial phase, only a few initiatives have been conducted. Based on the interview results with Tri Endah Yitnani (Head of Technology Planning Department, Bappeda Sleman) the initiative had started since 2008 by dissemination of the implication of a local SDI. In the following year the programme is enhanced by formulating local regulation draft as a foundation to implement local SDI for Sleman Government. So far, this rule is still under discussion and expected to be declared in 2010. Apart from legal development, the local government has begin to prepare a single-base map of Sleman Regency and plans to establish a project for creating metadata of all spatial data in the following year.

5.2. Institutional Arrangements

The institutional arrangement is reliant on successful partnerships and communication between agencies within and between jurisdictions. There are four possible information exchanges from an institutional perspective, specifically vertical, trans-vertical, horizontal and trans-horizontal (de Vries, 2006). In the context of Sleman Regency, information exchange between local agencies and national agencies is considered as trans-vertical. This can be found as Bappeda used and obtained spatial data (topographic maps) from Bakosurtanal to be used in their mapping programs. Meanwhile, information flows among different local agencies can be seen as trans-horizontal since they can exchange and share different spatial data, although it involved bureaucracy process. This is consistent with findings from the questionnaire survey which showed 81% of the respondent share spatial data with other local agencies.

Based on Presidential Act No. 85/2007 the local regency government is determined as one of network nodes of Indonesian SDI. The network node will select an institution responsible for implementing the acquisition, maintenance, update, and exchange of certain spatial data. Article 11 of the Act stated that each network node must establish a clearing unit to carry out the spatial data exchange and dissemination.

Sleman Regency as one of the network nodes is still preparing the institutional arrangements for local spatial data network. In the interview, Tri Endah Yitnani explained that Bappeda will be pointed as the institution which takes the responsibility to collect spatial data. Meanwhile, each local agency will has responsibilities to update and maintain the contents of spatial data according to their main functions. Event though it is not yet legally declared, Bappeda as the leading sector in the collection of spatial data will also has duty to ensure the data is in good quality. Additionally, Bappeda will be in charge on the development of metadata.

According to the interview result, Bappeda will be supported by Kantor Telematika which will be the clearing unit. Article 1 of the Act defined clearing unit as one of the working units in the network node which is assigned as the operator of spatial data exchange and dissemination. In addition, Kantor Telematika has responsibility in providing the data networks, including computer servers, routers, internet, and intranet connections. Kantor Telematika also has to make sure the spatial data can be exchanged effectively to the users.

5.3. Data

Spatial data available at Sleman Regency were come from different local agencies. The following table described the inventory.

Table 5-1: Spatial data available at Sleman Regency

No.	Theme	Contents	Provider	Scale	Format	Latest update
1.	Administrative boundary	village, sub-district	Bappeda	1:25,000	ArcGIS *shp*	2006
		village, sub-district	BPPD	1:5,000	ArcGIS *shp*	2006
2.	Environment	slope, geological, soil, forest resource, mine and mineral resource, geomorphologic, soil water reserve	Bappeda	1:25,000	ArcGIS *shp*	2005
3.	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
4.	Transportation	road network, transportation system	Bappeda	1:25,000	ArcGIS *shp*	2006
		road network	Dinas Kimpraswilhub	1:25,000	AutoCAD	2005
5.	Hydrology	river, irrigation system	Bappeda	1:25,000	ArcGIS *shp*	2007
6.	Utilities	electricity network, telecommunication	Bappeda	1:25,000	ArcGIS *shp*	2005
7.	Facilities	health facility	Dinas Kesehatan	--	ArcGIS *shp*	2005
		education facility, worship places, commerce facility	Bappeda	1:25,000	ArcGIS *shp*	2007
8.	Population	density	Bappeda	1:25,000	ArcGIS *shp*	2005
9.	Economics	gross regional domestic product, fishery production, rice production, industry, rice field distribution, crops plant	Bappeda	1:25,000	ArcGIS *shp*	2005
10.	Natural Hazards	Merapi volcanic risk, landslide, drought, cyclone	Dinas P3BA	1:50,000	ArcGIS *shp*	2004

It is clear that most of the spatial data 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. BPPD had started to utilize larger scale information from Ikonos image in 2005 and had produced administrative boundary and land parcel maps with scale of 1:5,000.

From the inventory we can identify there is duplication in term of spatial data provision. For example road network which was provided by Bappeda and also Dinas Kimpraswilhub. Although both of the data are in same scale but 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).

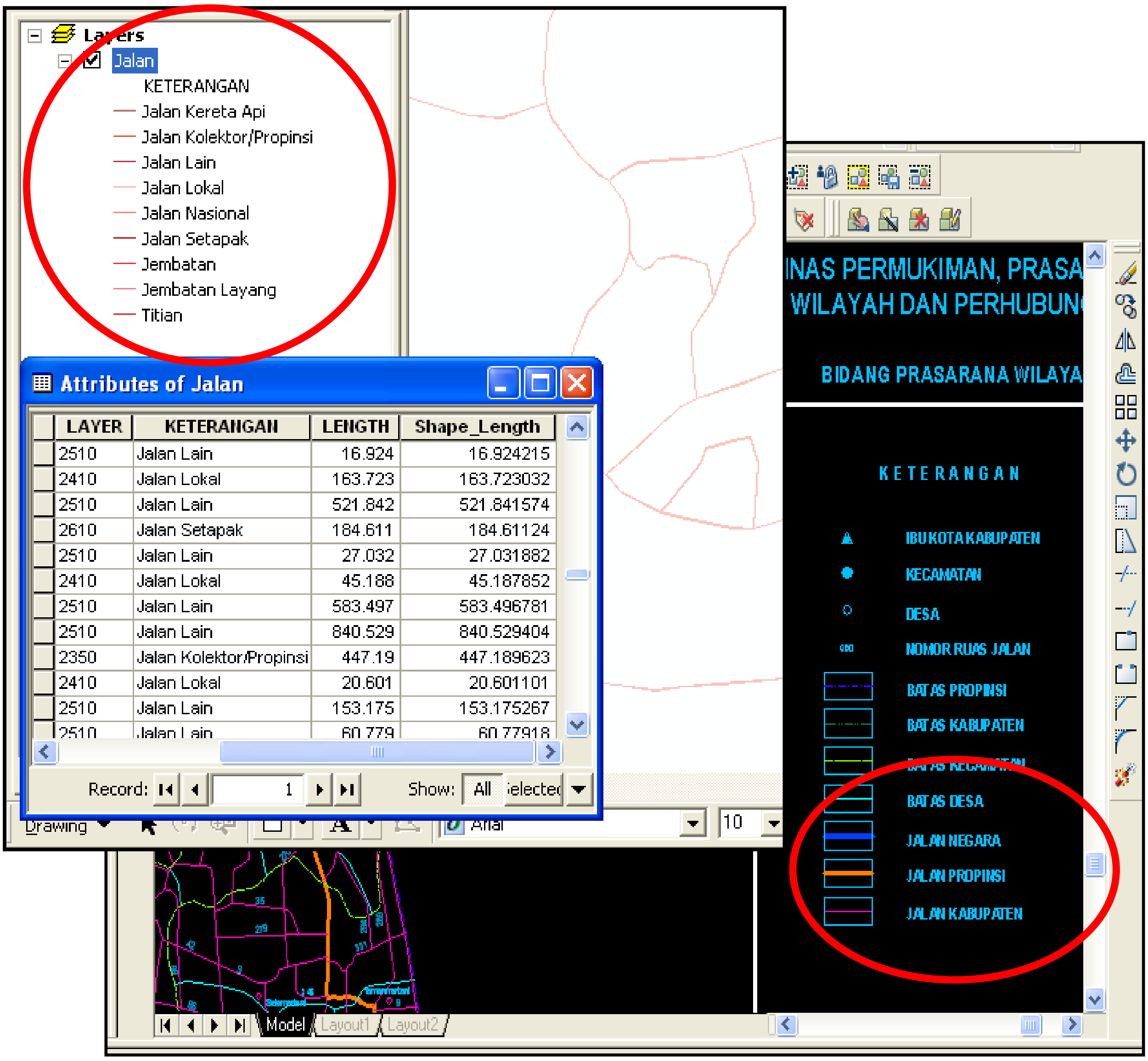


Figure 5-1: Different road cataloguing

Meanwhile, based on the questionnaire results all the institutions involved in Merapi volcanic risk management have spatial data whether in digital or hardcopy format. However, only about 27% of the spatial data are completed with the metadata. This indicates not all institutions are aware about the importance of metadata. The spatial data generally used in problem analysis, instruments in meeting and also tools for field survey. Questionnaire result for spatial data availability aspect is presented in Figure 5-2.

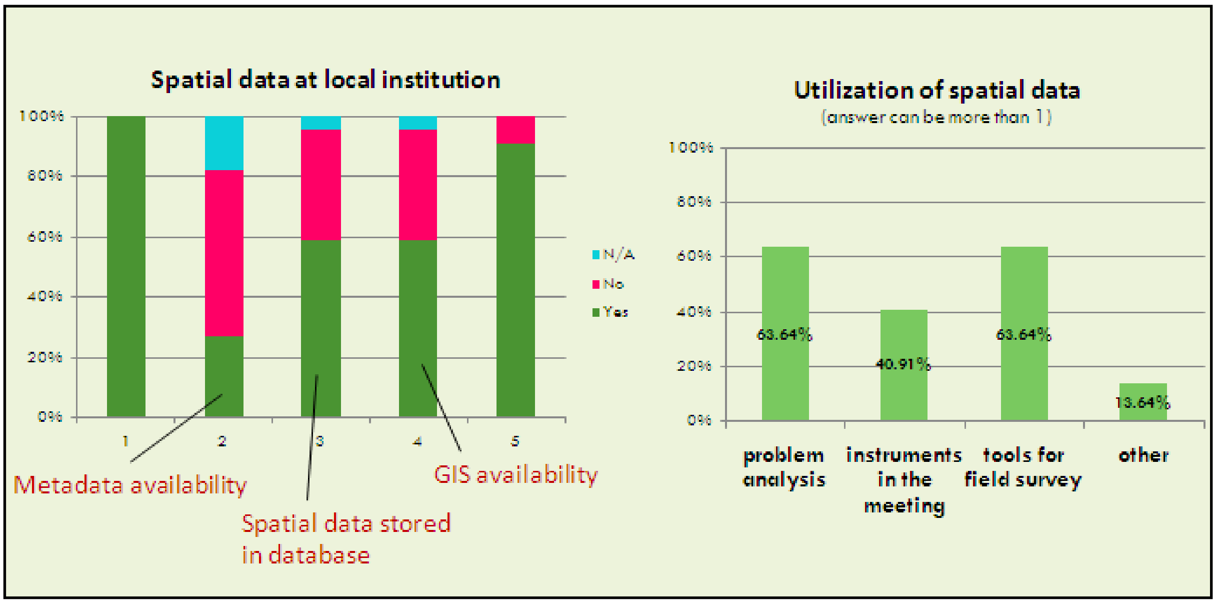


Figure 5-2: Respondents views of spatial data availability

In term 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 what spatial data are available at institutions, firstly by searching in the catalog and secondly by asking directly to official. All respondents were agreed that spatial data sharing is important, several reasons according to them are:

- It could provide policy/decision with the same point of view and most recent data
- It will support mapping programs/activities and effective planning programs conducted by local agencies
- It will grant the accuracy of the data and avoid data duplicity so it could reduce the budget
- It will promote data integration between agencies and urge the use of same standard

Table 5-2: Issues on spatial data access and sharing

No.	Issues	Yes (%)	No (%)
1	Difficult in accessing the spatial data from other agencies	31.82	68.18
2	Share spatial data with other agencies	81.82	18.18
3	Importance of spatial data sharing	100	0

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. The following figure described the result in the aspect of spatial data access and sharing.

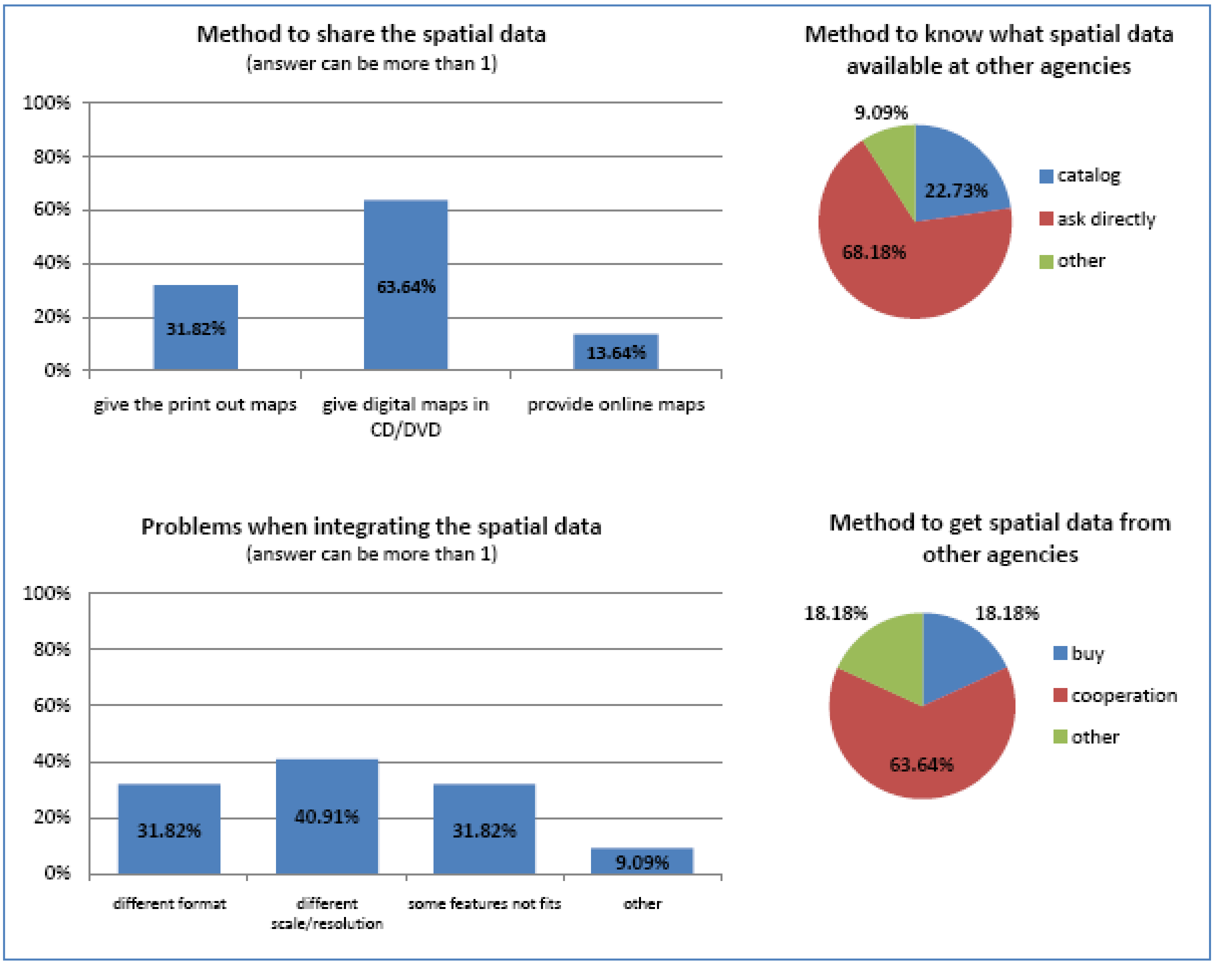
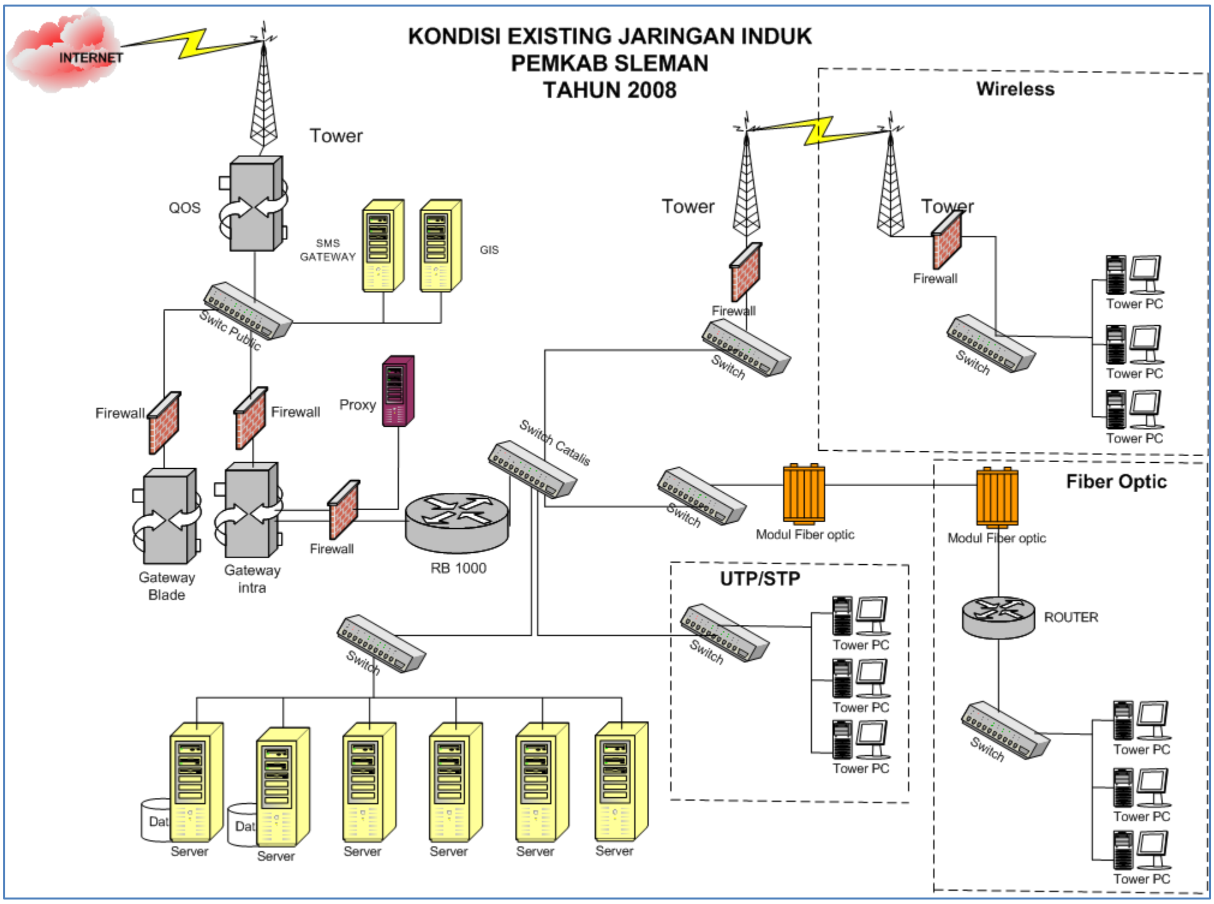


Figure 5-3: Questionnaire results about spatial data access and sharing methods

5.4. Technology

Technological aspects in implementation of a local SDI related with supplying a reliable network system for information exchange. It has to have the ability to transmit large volume spatial data as well as the abundant graphics. Nonetheless, it has to be compromised by some limitations of users such as the distance from network terminal and available hardware resources.

Development of Information and Communication Technology (ICT) at Sleman Government was started since 2003 through the *e*-Government programme (Majalah e-Indonesia, 2006). According to interview results with Eka Suryo from Kantor Telematika, the network system consists of two network types i.e. Intranet and Internet. Up to now, all local government offices at Sleman Regency were already connected to both network types. The Intranet is internal computer networks within local government offices that use Internet Protocol (IP) technologies to securely share any part of an agency's information or operational systems within that agency. It includes several information systems utilized by Sleman Government such as Information System of the Employment, Information System of the Payroll, and Information System of the Residence Administration. The Intranet network can only be accessed from authorized local agencies' computers. Meanwhile, Internet is used to connect to public computers and other external networks.



Source: Kantor Telematika

Figure 5-4: Network system of Sleman Government

From the figure above it can be seen that three technologies were used in the network system, specifically Wireless, Fiber Optics and Twisted Pair Cable. Wireless connections are used for local agencies which its building located relatively far from the data centre at Bupati office building and the building has possibility being renovated or moved in the short future. The Wireless also exploited to connect sub-districts offices with local government agencies. Fiber Optics is intended for agencies located around the local government offices complex, for example Bappeda, Dinas Pendidikan, and BKD. Lastly, Twisted Pair Cable is assigned to connect the working units or agencies which located in Bupati office building where the data centre exist. Kantor Telematika and Bidang Tapem are some of the instances.

Another considerable technical issue is utilization of GIS to support the local agencies in performing their function. From the questionnaire results showed in Figure 5-2, it can be said that more than 50% of the respondent employ GIS software and store the spatial data in database. This finding is validated by the author through in depth observation to several agencies, i.e. Bappeda, Dinas P3BA, BPPD and Dinas Kesehatan. As the result, these four agencies have been utilized *ArcGIS* software to help making maps and performing spatial analysis related with their tasks. However, not all of these agencies update their data continuously. One example was identified in the risk map of Merapi Volcano produced by Dinas P3BA which is based on population data in 2004 but still in use at present.

5.5. Human Resources

Development of local SDI requires skilled human resources in order to operate and maintain the system properly. As stated in Chapter 4 of Indonesian SDI Guidelines, the main manpower needed is in the field of information, communication, survey, and mapping technology. In the context of employees at Sleman Government, it can be found that there is limited human resource with the required GIS and related knowledge even though a number of local agencies have been utilized GIS software. Result from the questionnaire survey expressed that about 40% of the local agencies do not have GIS operator in their working unit. To improve the capacity, some activities have been conducted with the support from Bakosurtanal such as training and courses on GIS utilization and workshops on metadata development.

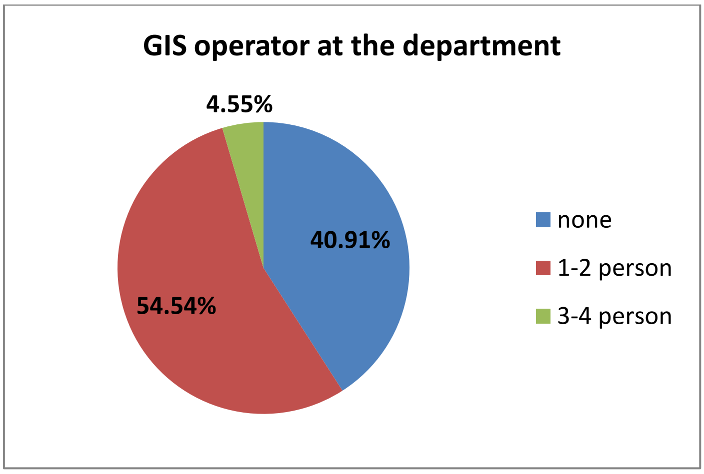


Figure 5-5: Questionnaire result on GIS operator availability

5.6. Gap Analysis

After identifying local SDI of Sleman Regency based on five foremost components, the author conducted comparative analysis in order to discover the gap between the current condition and the expected local SDI implementation. Presidential Act No. 85/2007 and Indonesian SDI Guidelines were used as reference of the expected one. The purpose of this gap analysis is to recognize which aspects of the existing condition need to be improved to achieve a functioning local SDI. The following table describes outcome of the analysis.

Table 5-3: gap analysis of the existing and expected local SDI implementation

Existing (based on interview and questionnaire results)	**Elements of SDI**	**Expected** (based on Presidential Act No. 85/2007 and Indonesian SDI Guidelines)
Regulation for the implementation of local SDI is not established yet. Still in progress formulating draft of the Bupati act	**Regulation**	▪ Regulation to arrange implementation of a local SDI which could be in the form of local rules or Bupati act *(stated in Chapter 3 of the Guidelines)*
▪ No official arrangements on which institution responsible as the coordinator and as the clearing unit ▪ Each local institution collecting/obtain spatial data based on their own interests without any obligation	**Institutional Arrangements**	▪ The local government should decides on institutions act as the coordinator and as clearing unit for local SDI *(Chapter 4 of the Guidelines and Article 11 of the Act)* ▪ Custodianship to organize the rights and responsibilities of each local agency for the collection of spatial information *(Chapter 3 of the Guidelines)*
▪ Each local institution used different specification on feature cataloging ▪ Most of spatial data do not have the metadata ▪ Not all of the spatial data can be accessed by public ▪ Started to apply National Metadata Standard	**Data**	▪ Use the same standard or specifications regarding the spatial data *(Article 8 of the Act)* ▪ Spatial data complemented with the metadata *(Chapter 4 of the Guidelines)* ▪ Provide spatial data that is accessible to public *(Article 6 of the Act)*
▪ Data access network is available through intranet/internet ▪ Metadata catalog is not available yet ▪ Local institutions have been utilizing GIS	**Technology**	▪ Establishment of data access network *(Article 6 of the Act)* ▪ Establishment of metadata catalog as the gateway to provide spatial data information *(Chapter 3 of the Guidelines)* ▪ Utilization of ICT, GIS, GPS and related technologies *(Chapter 4 of the Guidelines)*
Limited human resources with GIS and related field knowledge	**Human Resources**	▪ Availability of adequate human resources in GIS field *(Chapter 4 of the Guidelines)* ▪ Certification and accreditation of the profession of survey and mapping *(Chapter 3 of the Guidelines)*

5.7. Concluding Remarks

Local SDI consists of five major elements i.e. regulation, institutional arrangements, data, technology and human resources. Sleman Government, already aware with the potential benefit of a local SDI has started to perform several initiatives. Nevertheless, result of gap analysis between the existence and expected local SDI implies several issues that need to be considered in the implementation as follow:

1) Local SDI of Sleman Regency requires prevailing regulation to enforce and organize the stakeholders.
2) Local SDI of Sleman Regency has to establish institutional framework which comprises a local coordinator and a local clearing unit.
3) Local SDI of Sleman Regency will service larger scale spatial data than national SDI; therefore it has to develop particular framework data to support the large scale spatial data.
4) Local SDI of Sleman Regency must be involved into standardization process, to harmonize local specialities with national standards and urge on local standardization progress.
5) Local SDI of Sleman Regency has to supply metadata information in order to facilitate information retrieval by the users.
6) Local SDI of Sleman Regency has to be supported by reliable access network system.
7) Continuous capacity building in the aspect of human resources is needed in the development of Local SDI of Sleman Regency.

6. DESIGN AND IMPLEMENTATION OF THE PROTOTYPE

This chapter describes requirements from the respondents related to evacuation planning. The design and development of the prototype based on these requisites were explained in subsequent sections.

6.1. User Requirements

The fieldwork 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 6.1 lists these data types. Data about evacuation infrastructure is maintained by Dinas P3BA while the hazard map is provided by BPPTK.

Table 6-1: Requirement of spatial data for evacuation planning

No.	Spatial data theme	Attributes	Data provider
1	Evacuation roads	name, location, length	Dinas P3BA
2	Evacuation barracks	name, location, size, capacity, facility, condition	Dinas P3BA
3	Health facilities	type, name, location	Dinas Kesehatan
4	Village administrative map	name, extent, boundary	Bappeda
5	Volcanic hazard map of Merapi Volcano	hazard area, hazard types	BPPTK
6	Population in the hazard zones	number of population, households, man, women, children, disabled people, pregnant women, elderly	Bappeda

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 (Figure 6-1). 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.

Table 6-2: Respondents' opinion about the requirement of Geospatial Web Service

No.	Issues	Yes (%)	No (%)	N/A (%)
1	Spatial data can be accessed via internet/intranet	100	0	0
2	Service for data discovery	90.91	0	9.09
3	Service for data visualization	95.45	0	4.55
4	interactive maps service	90.91	0	9.09

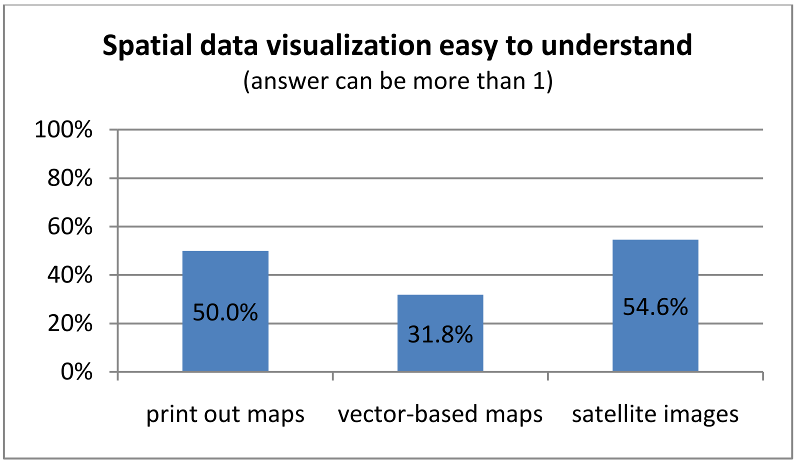


Figure 6-1: Perceptions of the respondents regarding spatial data visualization

In addition to the prerequisites resulting from survey, there were additional requirements in terms of information sources and needs during evacuation process. Examining the standard operation procedure of emergency response stated in the Bupati act of Sleman Regency No. 83/Kep.KDH/A/2006 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 6-3.

In the pre-evacuation phase, it is clear that the four agencies require information concerning the alert level from BPPTK. 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 6-3: Information needs in evacuation process

Institution	Pre-Evacuation	During Evacuation	Post-Evacuation
Dinas P3BA	- hazard zones - notification of alert level from BPPTK - 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

Table 6-3: ***(continued)***

Institution	Pre-Evacuation	During Evacuation	Post-Evacuation
Dinas Kimpraswilhub	- notification of alert level from BPPTK - 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 BPPTK - 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 BPPTK - susceptible population number - location of evacuation barracks - potential location of public kitchen	- number of people evacuated in barracks - supply of the logistics (food supply, blanket, mattress, etc)	logistics remains in the warehouse

6.2. Design of The Prototype

Having identified user requirements in the previous section, the subsequent step was to design the prototype. The requirements were represented in a visual model using UML. As mentioned in Chapter 2, 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 use diagram describes which actors are involved and which actors have which roles in evacuation planning. The use case diagram in Figure 6-2 identifies seven institutions with significant functions. This model was used as the basis to determine the users who will operate the prototype.

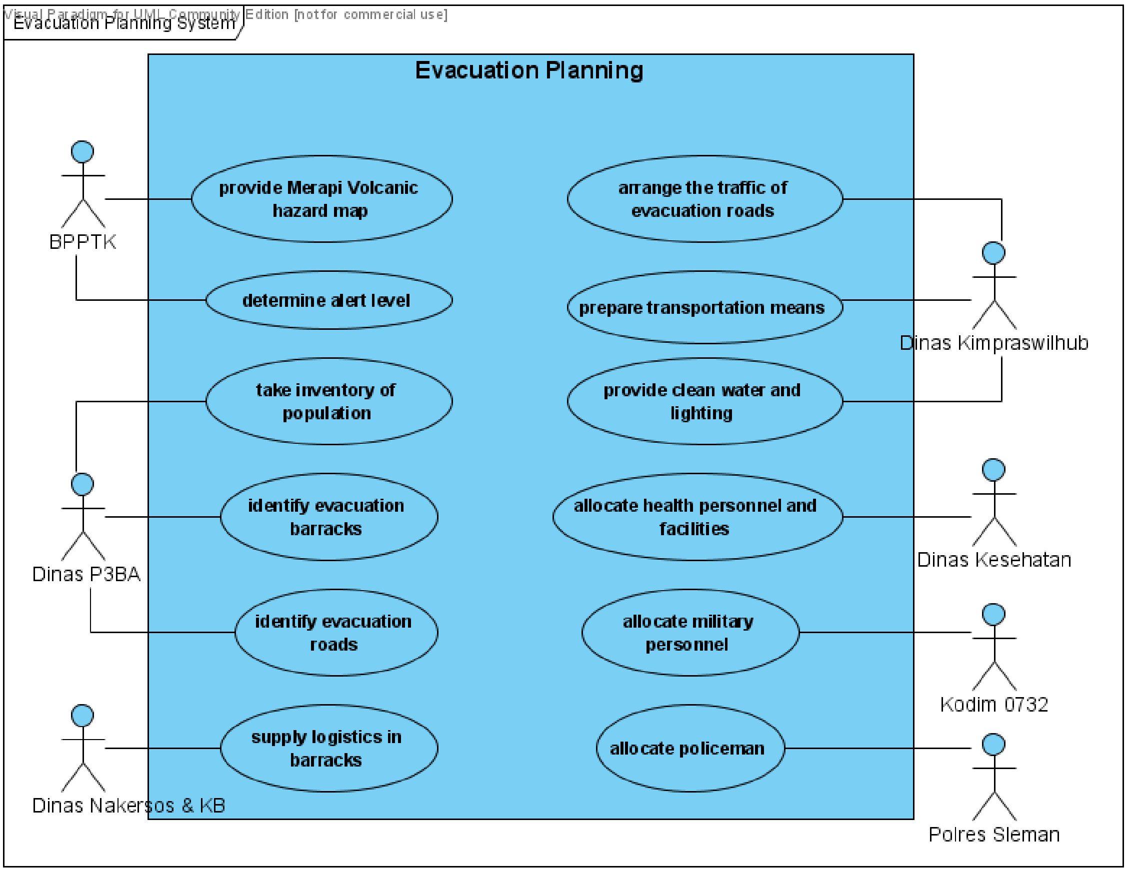


Figure 6-2: Use case diagram of the evacuation planning system

Secondly, a UML sequence diagram helped 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 in Figure 6-3 represents six main objects, namely: Login Panel, Google Maps Panel, WMS Layer Panel, Metadata, MapServer and Database.

Five actions of users can be identified through the diagram. 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. A last action required by a user is to log out from the system.

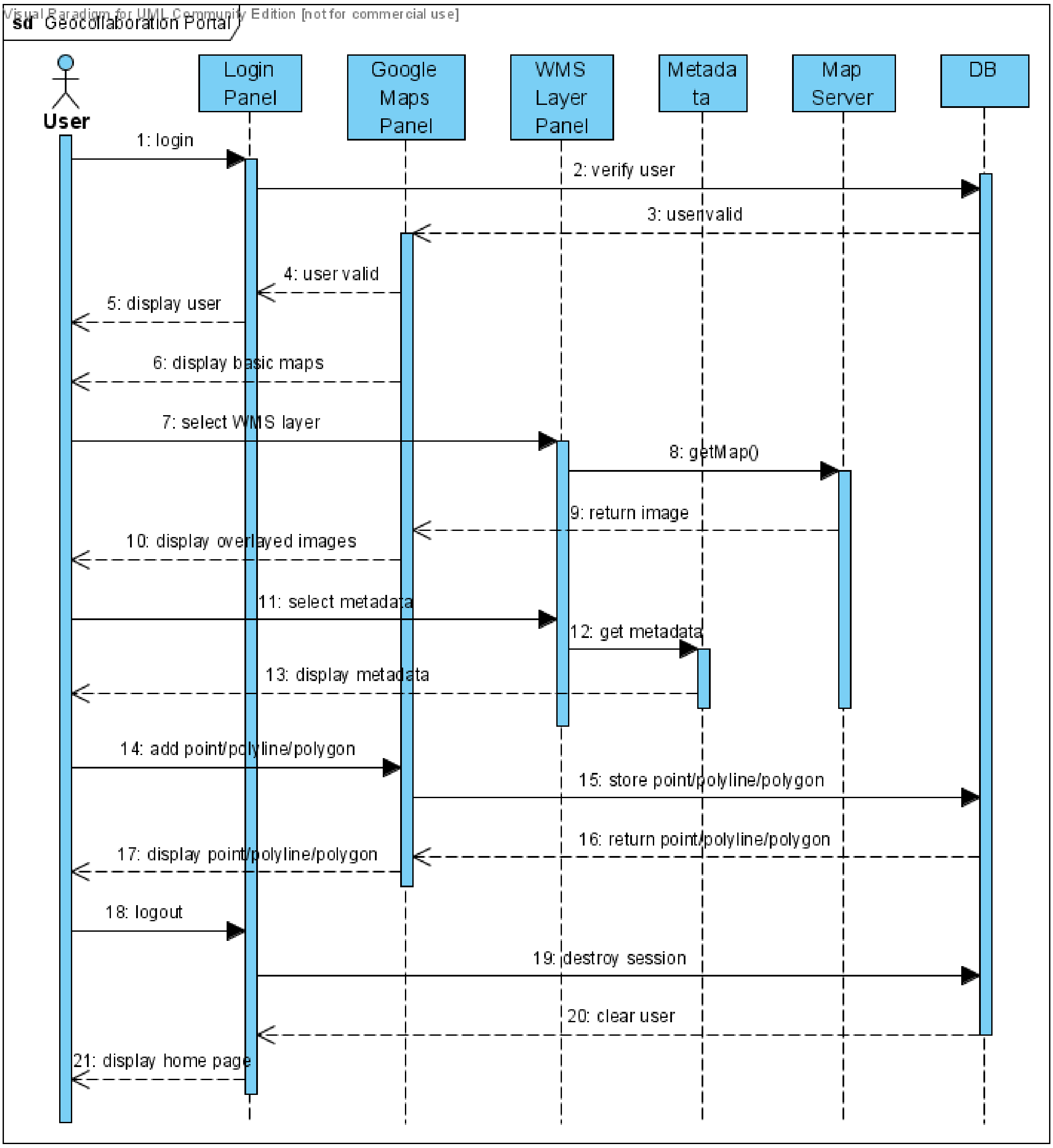


Figure 6-3: General sequence diagram of the prototype

An example of a detailed sequence diagram for evacuation planning is presented in Figure 6-4. Based on the use case diagram, 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.

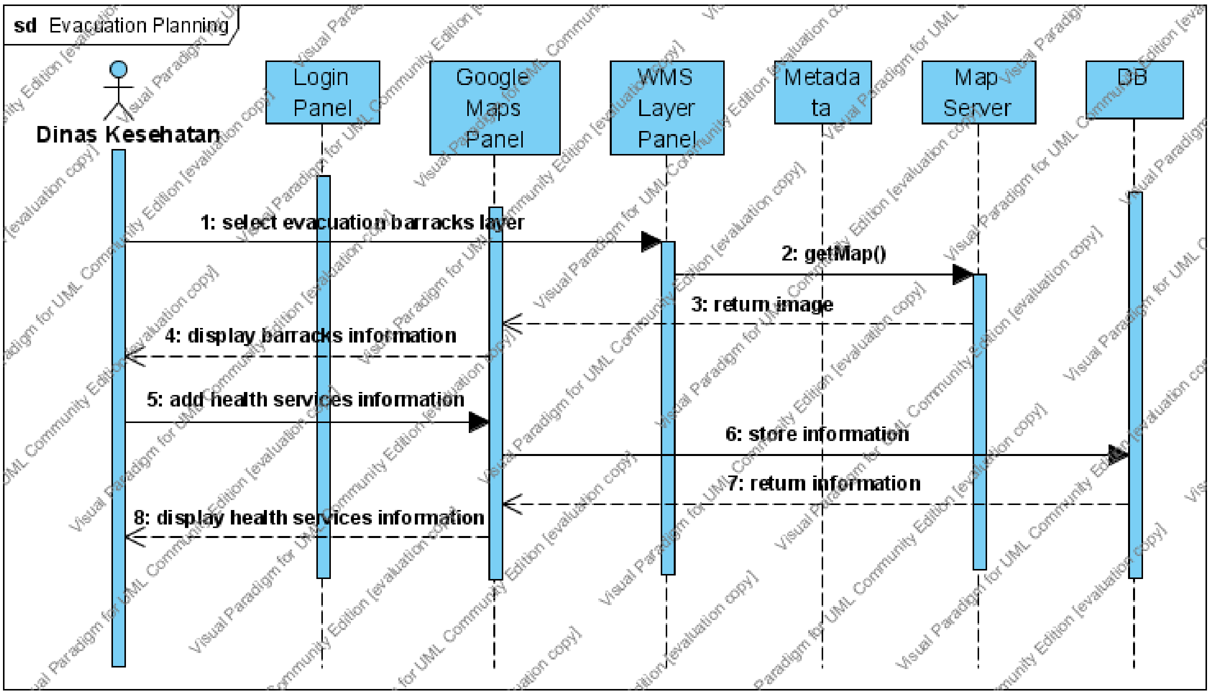


Figure 6-4: Sequence diagram of the allocation of health services

6.3. Development of The Prototype

As stated earlier in the Chapter 3, there were two stages in developing the prototype. Firstly, there was the creation of the geospatial web services required in the prototype; and, secondly, there was the customization of the GeoCollaboration Portal. The collection of data required for evaluation planning (listed in Table 6.1.) 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.

6.3.1. Geospatial Web Services Development

One of the user requirements is to provide a portrayal service in the prototype. OGC Web Map Service (WMS) and OGC KML (formerly Keyhole Markup Language) could accommodate this prerequisite. WMS is a standard protocol for serving georeferenced map images over the Internet that are generated by map server using data from a GIS file. WMS maps can be presented in a pictorial format such as PNG, GIF or JPEG, or as vector-based graphical elements in Scalable Vector Graphics (SVG) format. The OGC defines KML as an XML language focused on geographic visualization, including annotation of maps and images. Geographic visualization includes not only the presentation of graphical data on the globe, but also the control of the user's navigation in the sense of where to go and where to look. From this perspective, KML is complementary to most of the key existing OGC standards including GML, WFS and WMS.

Implementing OGC WMS

MapServer was the software tool used to implement the WMS instances. It is a popular open source project, originally developed by the University of Minnesota, United States. 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 following piece of code is an example of a Mapfile to generate a WMS for sub-districts boundary data:

```
MAP
   NAME         Batas_Kecamatan
   IMAGETYPE    PNG
   EXTENT       427584.764600 9148532.4705 442386.1181 9165674.9858
   STATUS       ON
   UNITS        METERS
   SIZE         600 600
   SHAPEPATH    "c:\mapfile_sleman\shp"
   FONTSET      "c:\mapfile_sleman\font\font.dat"
   SYMBOLSET    "c:\mapfile_sleman\simbol\simbol.sym"
   IMAGECOLOR 255 255 255
#
   WEB
            IMAGEPATH "c:\temp\"
            IMAGEURL "c:\temp\"
            METADATA
              WMS_TITLE "Batas Kecamatan Turi, Pakem dan Cangkringan"
              WMS_ABSTRACT "WMS Batas Kecamatan Turi, Pakem dan Cangkringan"
              WMS_SRS "EPSG:4326"
              WMS_ONLINERESOURCE "http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&mode=map"
            END
   END
   PROJECTION
    "init=epsg:4326"
   END
#
   LAYER
     NAME     Batas_Kecamatan
     DATA     Admin_3_Kec_Line
     STATUS   ON
     TYPE     LINE
     METADATA
        WMS_TITLE "Batas Kecamatan Turi, Pakem dan Cangkringan"
        WMS_SRS "EPSG:4326"
     END
     PROJECTION
        "init=epsg:4326"
     END
     CLASS
       NAME   "Batas_Kecamatan"
        STYLE
          SYMBOL "GarisCDash"
          COLOR 0 0 0
          SIZE 2
        END
      END
```

```
    END
END
```

The OGC Web Map Services are able to handle two mandatory requests; the first one is a GetCapabilities, which returns an XML document with metadata of the Web Map Server's information; and the second one is a GetMap, which returns an image of a map according to the needs which a user has indicated. In addition, some optional requests are also supported, such as GetFeatureInfo and GetLegendGraphics.

After having created a Mapfile, the next step is to check whether both of the requests are able to run in the WMS Server. To test the GetCapabilities request, one can use an internet browser to access the WMS Server's online resource URL and add the parameters "SERVICE" and "REQUEST" to the end. An example of the GetCapabilities request for the WMS of Sub-district boundary looks like this:

http://localhost/cgi-bin/mapserv.exe?map=c:\mapfile_sleman\wms_batas_line.map&SERVICE=WMS&VERSION=1.1.1&REQUEST=GetCapabilities"

The response to this GetCapabilities request is an XML document which describes the service, its content and the supported operations. Appendix 4 presents the XML file for the service.

To test the GetMap request there are some additional parameters needed in the URL. These parameters are:

- VERSION=version: WMS Service request version
- REQUEST=GetMap: Request name
- LAYERS=layer_list: Comma-separated list of one or more map layers. Optional if Styled Layer Descriptor (SLD) parameter is present.
- STYLES=style_list: Comma-separated list of one rendering style per requested layer.
- SRS=namespace:identifier: Spatial Reference System (SRS).
- BBOX=minx,miny,maxx,maxy: Bounding box corners (lower left, upper right) in SRS units.
- WIDTH=output_width: Width in pixels of map picture.
- HEIGHT=output_height: Height in pixels of map picture.
- FORMAT=output_format: Output format of map.

An example of the GetMap request to the Sub-district boundary service is:

http://localhost/cgi-bin/mapserv.exe?map=c:\mapfile_sleman\wms_batas_line.map&SERVICE=WMS&VERSION=1.1.1&REQUEST=GetCapabilities&LAYERS=All&STYLES=&SRS=EPSG:4326&BBOX=427584.764600,9148532.4705,442386.1181,9165674.9858&WIDTH=600&HEIGHT=600&FORMAT=JPEG

The GetMap response returns the map based on specific parameters to the WMS client. Some software such as *ArcMap*, *Quantum GIS*, and *uDig* are providing WMS client support. Figure 6-5 presents the WMS of Sub-district boundary of *Kecamatan* Pakem, Turi and Cangkringan accessed from ArcMap version 9.2.

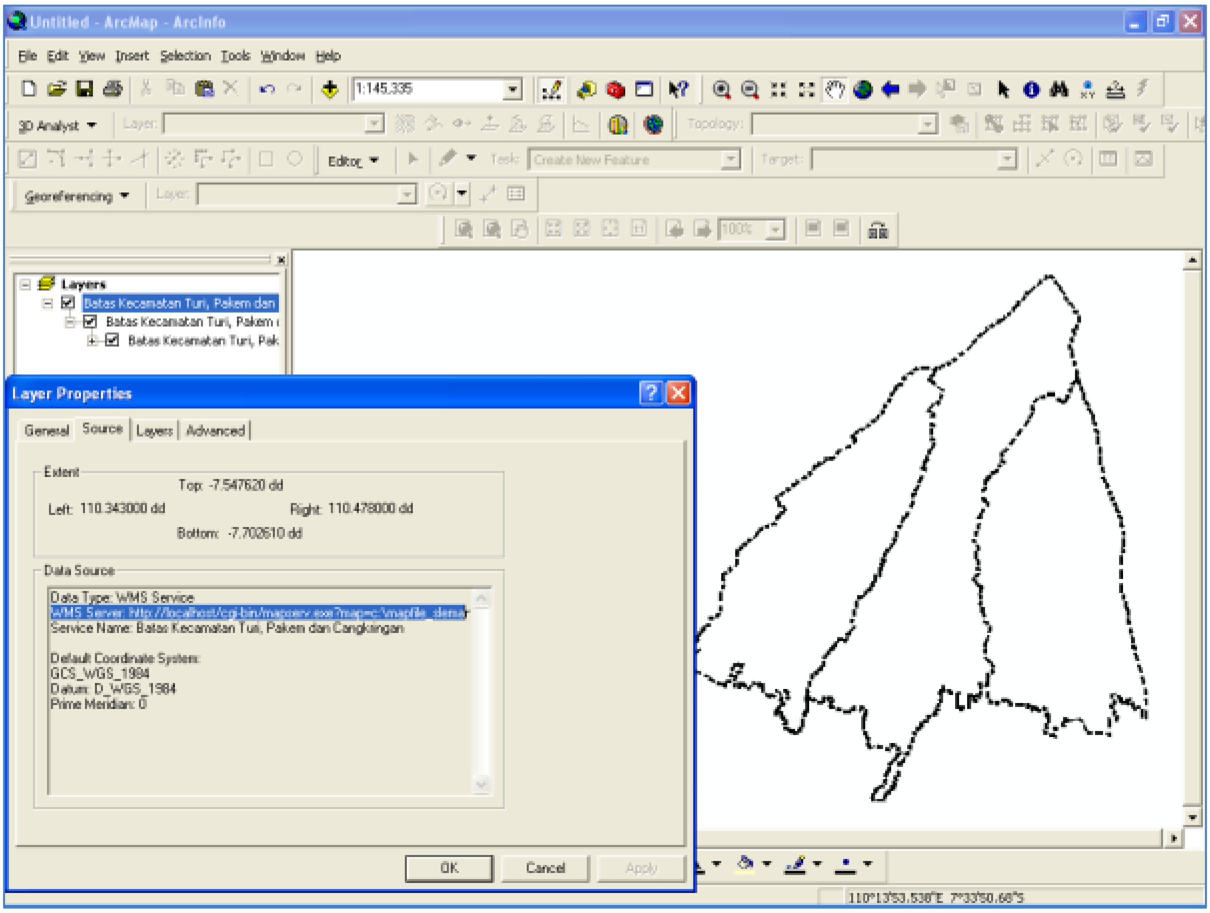


Figure 6-5: WMS of the Sub-district boundary dataset

Implementing OGC KML

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* by the Bureau of Planning, City of Portland. The extension allows ArcMap users to export any point, polyline, or polygon dataset in KML format.

Steps of creating the KML file using the extension are as follow:

a. At first select the point, polyline, or polygon dataset that can be in any *ArcGIS* format – *shapefile*, *coverage*, or *geodatabase*. The layer must have a defined spatial reference.

b. Secondly, from the optional field choose an attribute in the layer that will be used to create feature label in the output KML. Another optional input is the checkbox to group and color features using the layer's symbology.

c. Lastly, type the file name and directory location of the KML file that will be created.

Figure 6-6 shows an example of the process of creating KML file for the Merapi volcanic hazard zones dataset. Content of the KML file is presented in Appendix 5.

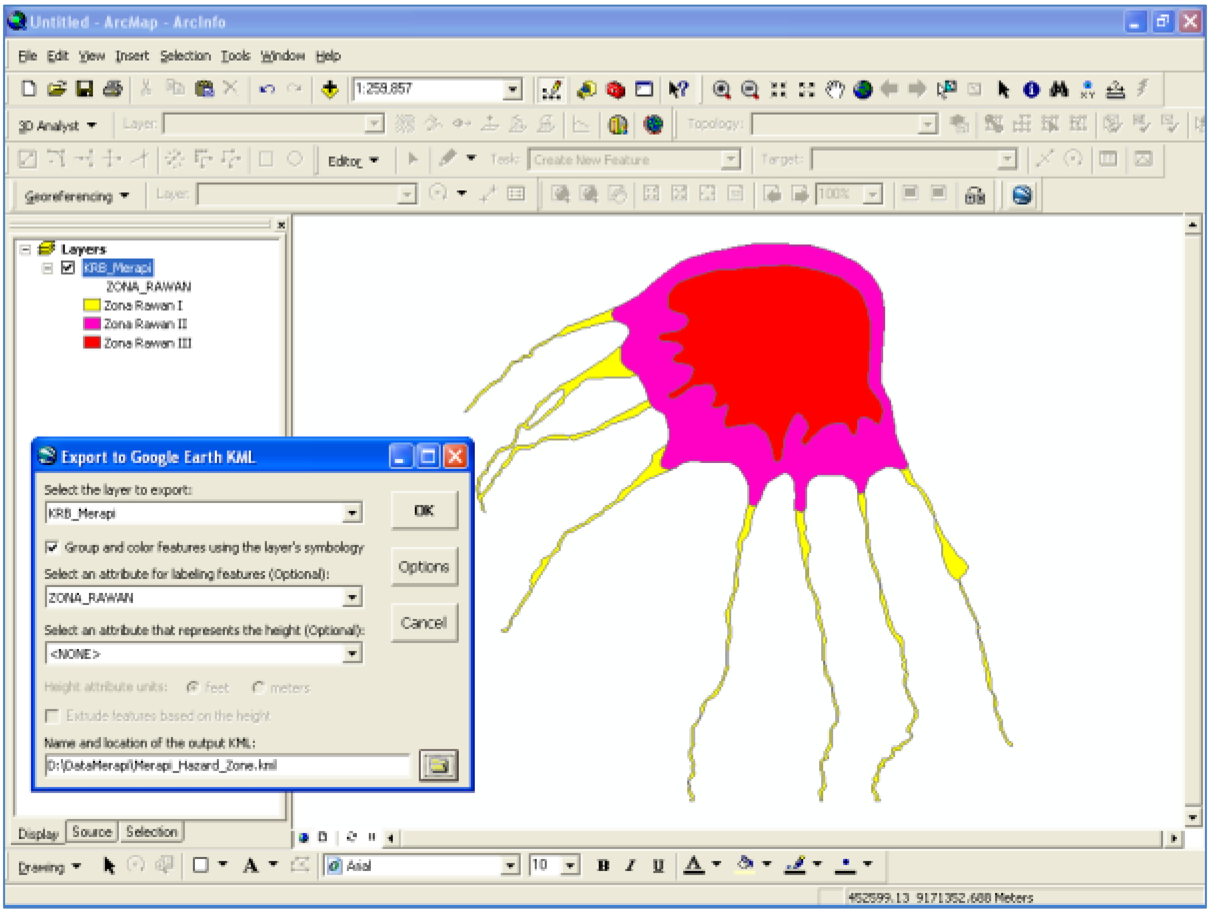


Figure 6-6: Creating KML file for Merapi volcanic hazard zones dataset

With *Google Earth* the KML file – as illustrated in Figure 6-7 – could be tested.

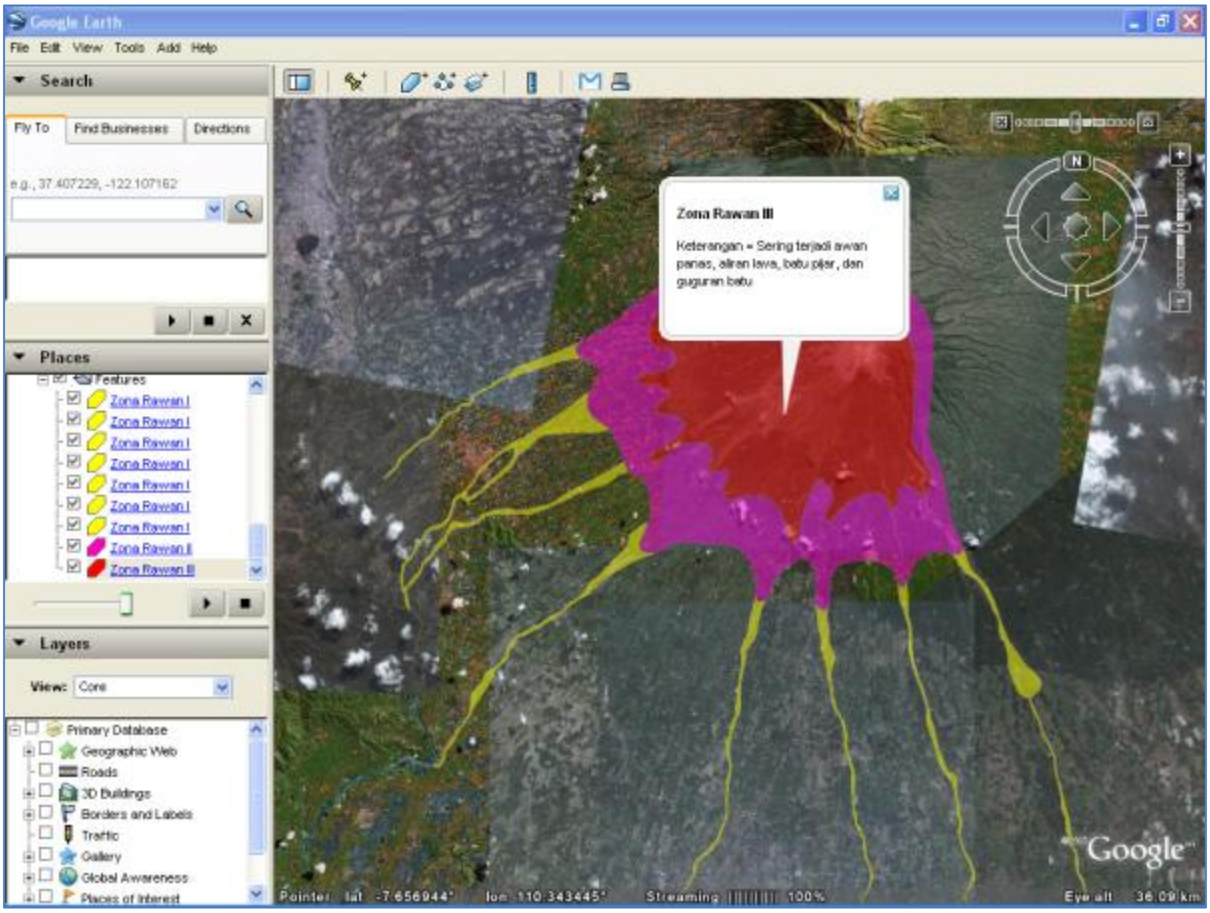


Figure 6-7: KML file in *Google Earth*

The KML file was encoded as a layer in *Google Earth*, described in Figure 6-7. The hazard zones layer was correctly located around Merapi Volcano area. The attribute of the layer could be displayed by clicking the specific features on the map.

6.3.2. Customization of The GeoCollaboration Portal

The GeoCollaboration Portal consists of three fundamental layers, namely a data layer, a metadata layer, and a presentation layer. The data layer provides spatial resources, in this case, geospatial web services, intended to support data analysis. The metadata layer is stored as tables and is designed to provide information about user actions, group interactions and portal sessions. The presentation layer is developed as the map interface, which enables distributed visualization. Various data layers from different agencies are presented as WMS compliant, so that they can be cascaded synchronously on the map interface (Aditya, 2008).

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 in the prototype: the Sub-district boundary, the Merapi volcanic hazard zones, the village administrative boundaries, the evacuation barracks, the evacuation roads, and the Health facilities (*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. Different from the metadata layer mentioned in the first paragraph of section 6.3.2, these 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. One last 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.

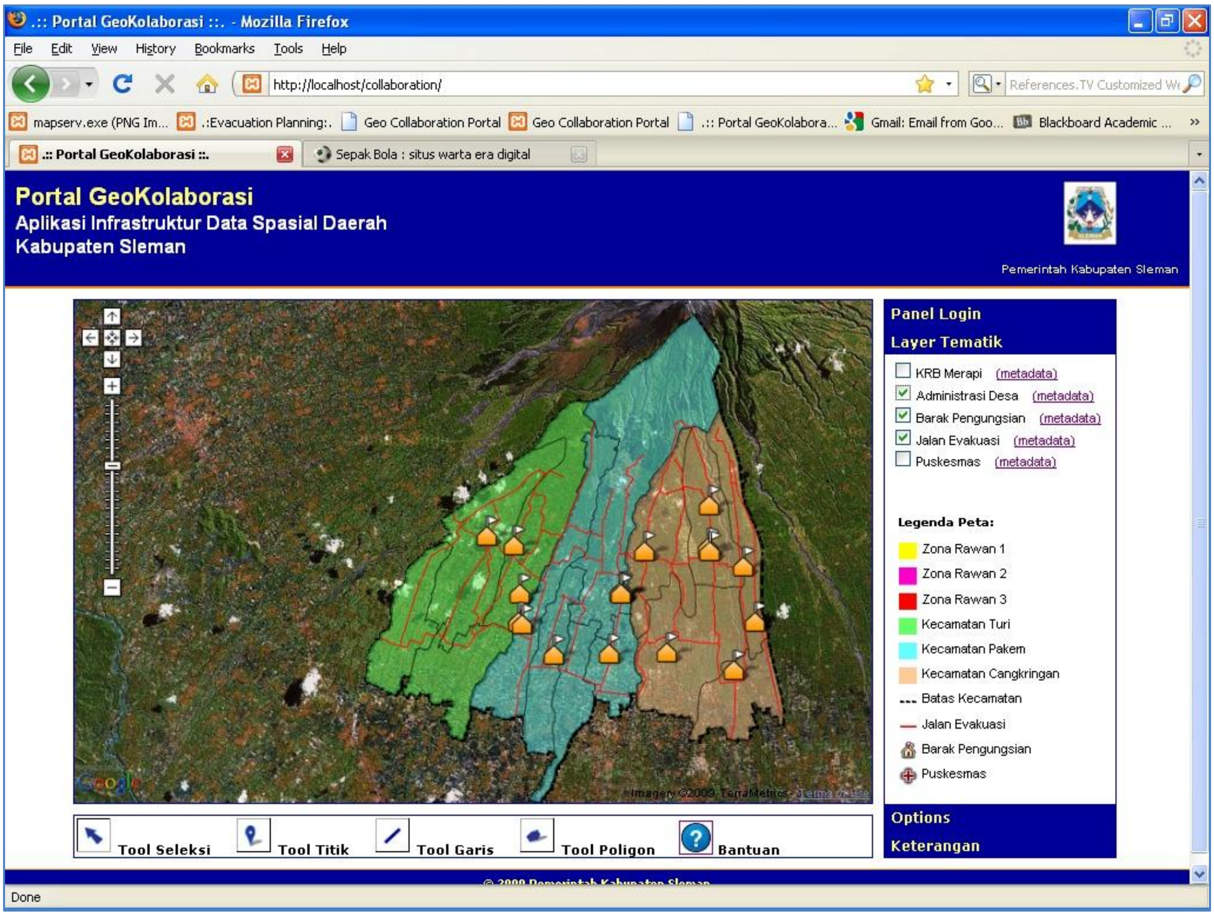


Figure 6-8: Interface of the prototype

Figure 6-8 presents the interface of the prototype after the subsequent customizations were made. After a successfully user login to the prototype, the Sub-district boundary layer will be displayed together with the Google Maps presentation. The other spatial resources which are required for evacuation planning can be selected in the Thematic Layer Panel. The metadata of each spatial resource can be accessed by clicking metadata label next to the layer's name. The map legend is placed below the spatial resource list. The help file is located in the Map Toolbox together with the Selection Tool, Point Tool, Line Tool and Polygon Tool.

A user displayed attributes of the data layer by clicking the objects on the map. For example to show attributes of the evacuation barracks layer, a user clicks on one of the barracks and he or she will be shown the information as presented in the following figure.

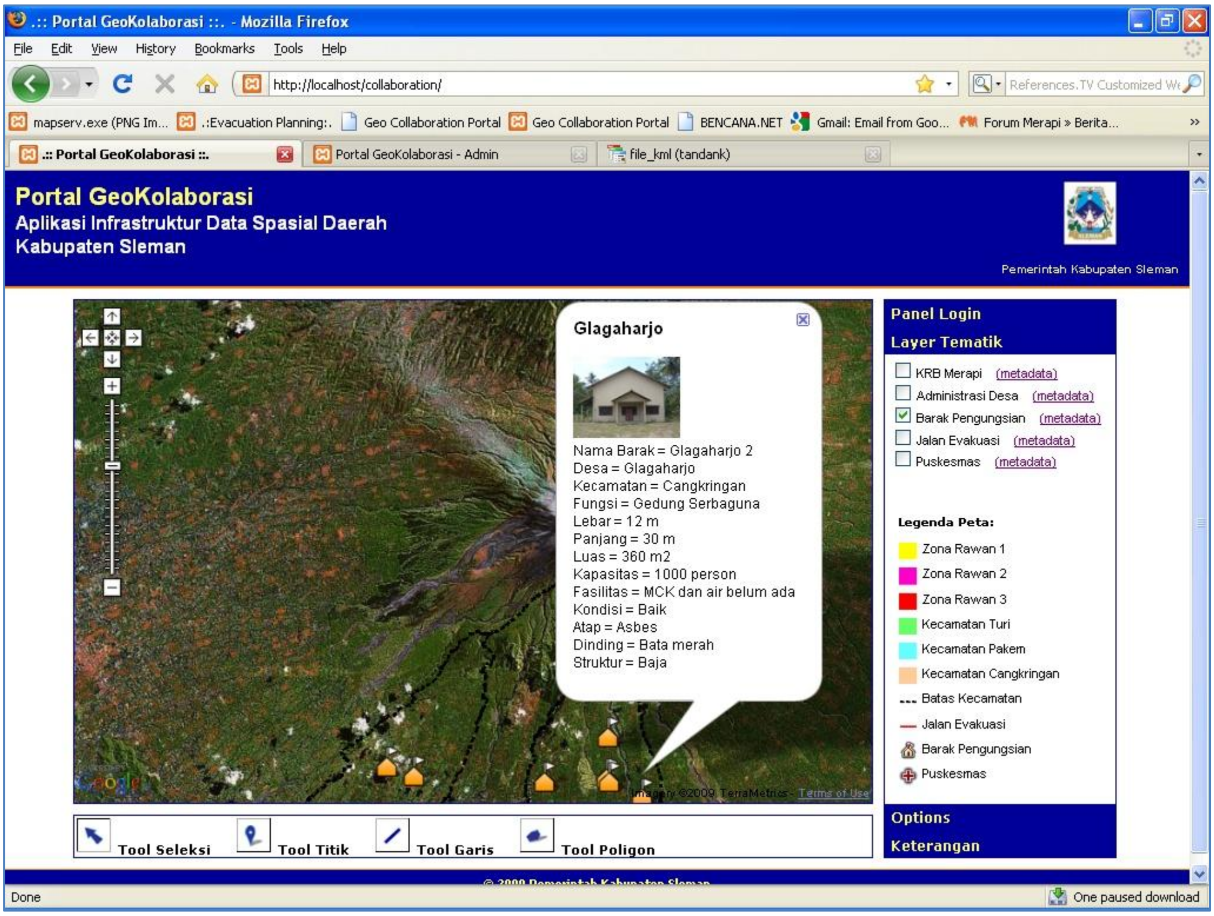


Figure 6-9: Attributes of the data layer

As described in the sequence diagram in the design phase, the prototype helps a user to draw point, line or polygon with its associated annotations. To perform this, the user has to utilize the Point Tool for adding new point information; the Line Tool to create new line; and the Polygon Tool to draw new polygon on top of the map. This information is saved in the database and is automatically displayed in the map.

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 & KB. The administrator page of the prototype is illustrated in Figure 6-10.

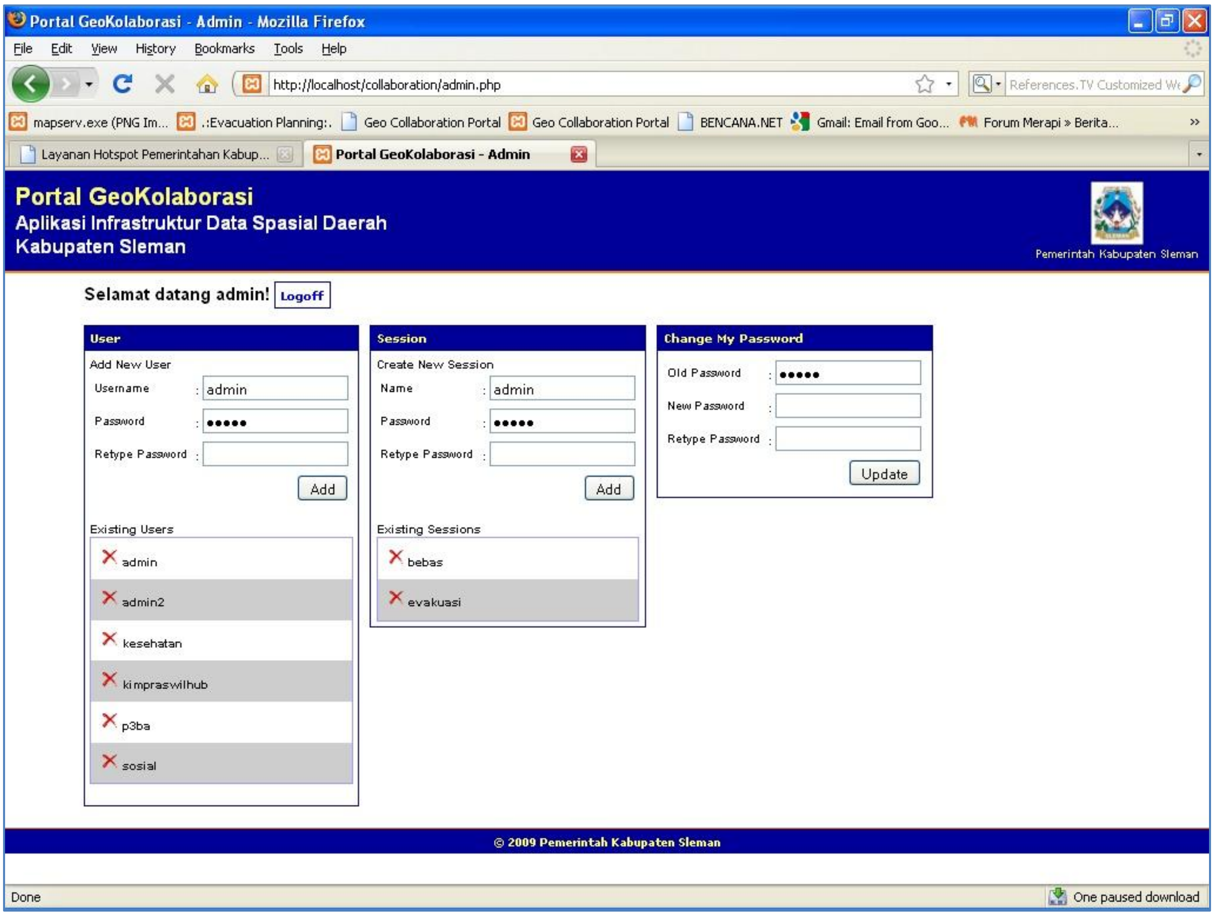


Figure 6-10: Administrator page of the prototype

6.4. Concluding Remarks

The construction of the prototype started from the determination of the user requirements which were gathered during the fieldwork. These requirements related to the spatial data provision and geospatial web services needed by the user. Additionally, information sharing requirements of the local agencies involved in evacuation process was presented. With these, it was possible to generate two UML diagrams enabling the visualization of the conceptual components of the prototype. A use case diagram helped to describe the actors of the evacuation planning system along with their functions. Meanwhile, a sequence diagram was generated to visualize series of actions that can be performed by the user and interactions of the objects in the prototype.

The prototype along with the UML diagrams respond to one of the research questions in this study, namely that of which technology can be used to implement the application of a local SDI. By deploying a geoportal and geospatial web services in the prototype it is possible to combine different data sources and make these usable for disparate users. Moreover, the portal provides spatial data resources, metadata layer and interactive map presentation that can be exploited to help evacuation planning activities. WMS and KML files supply the spatial data to the Portal. These layers represent various data resources possessed by the local government agencies. Information regarding metadata of each spatial resource was also attached to the prototype.

7. EVALUATION OF THE PROTOTYPE

This chapter provides explanation on the process and the results of evaluation of the prototype. Assessment results on the aspects of usefulness, effectiveness, satisfaction and accessibility will be discussed. In addition some remarks during testing session and group discussion were presented.

7.1. Overview

The purpose of conducting 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.

To achieve those purposes the following explicit questions were generated for this test as follows (this list based on pragmatic concerns identified in the previous chapter):

a) How do users feel about the user interface?
b) How easy can users access the application?
c) How easy do users login to the application?
d) How easy can users explore the maps presentation?
e) Can users access the application using different internet browser?
f) How successful can users find related information regarding evacuation planning?
g) Can users perform specific task for evacuation planning?
h) Do users find their own data and data of others in the application?
i) Does the application useful in facilitate synchronous information sharing that can be used for evacuation planning?
j) Does the application provide facility to create information on maps (annotation) that can be used for evacuation planning?
k) Does the metadata provide enough information of spatial data to the users?
l) Does the spatial data provided in the application appropriate with the requirement for evacuation planning?
m) Does the application help to coordinate local agencies in supporting the evacuation planning?

From those questions several hypotheses were determined. These hypotheses allow for the creation of evaluation scenarios and tasks. These hypotheses are:

1. Participants believe that the user interface and content of the prototype is satisfied
2. Participants will be able to access the application easily
3. Participants will be able to login to the application easily

4. Participants will be able to explore maps presentation easily
5. Participants will be able to access the application with different internet browser
6. Participants will be able to locate information regarding evacuation planning
7. Participants will be able to perform task for evacuation planning
8. Participants will be able to find their own data and data of others in the application
9. The application is useful in facilitate synchronous information sharing
10. Participants will be able to create new information on maps
11. Participants will be able to gather information from the metadata
12. Spatial data provided in the application were accordance with the requirement
13. The application will be able to help coordinate local agencies in evacuation planning activities

Data collected in the test includes performance and preference data. Performance data consist of objective measures of behavior such as the number of errors occurred when completing the task. This type of data usually derived from observation of either the live test or review of the video recording after the test has been done. Meanwhile preference data refers to more subjective data that measures a participant's feelings or opinions of the product. This data is typically collected via written, oral, or even online questionnaires. An example of this type of data is a rating scale of user satisfaction of the product (Rubin and Chisnell, 2008). The following table presents relationship between usability aspects being assessed, questions, and the data collection method.

Table 7-1: Usability aspects being assessed in the evaluation

Usability Aspect	Evaluation Question	Data Collection Method
Usefulness	1. Does the application useful to facilitate synchronous information sharing that can be used for evacuation planning?	Questionnaire
	2. Does the spatial data provided in the application appropriate with the requirement for evacuation planning?	Questionnaire
	3. Does the application provide facility to create information on maps (annotation) that can be used for evacuation planning?	Questionnaire
	4. Does the application help to coordinate local agencies in supporting the evacuation planning?	Questionnaire
Effectiveness	5. How easy do users login to the application?	Questionnaire
	6. How easy can users explore the maps presentation?	Questionnaire
	7. How successful can users find related information regarding evacuation planning?	Observation
	8. Can users perform specific task for evacuation planning?	Observation
	9. Do users find their own data and data of others in the application?	Questionnaire

Table 7-1: ***(continued)***

Usability Aspect	Evaluation Question	Data Collection Method
Satisfaction	10. How do users feel about the user interface and content of the prototype?	Questionnaire
	11. Does the metadata provide enough information of spatial data to the users?	Questionnaire
Accessibility	12. How easy can users access the application?	Questionnaire
	13. Can users access the application using different internet browser?	Observation

Participants of user group test were representatives from local agencies which had significant roles in evacuation planning of Merapi Volcano Disaster. In addition, the group of invitees consisted of officials from Dinas P3BA, Dinas Kimpraswilhub, Dinas Kesehatan, Dinas Nakersos & KB. Finally, Bappeda was also invited since it has a significant role in the implementation of the local SDI. Participants were assumed to be familiar with internet applications, and were assumed to have knowledge of evacuation planning activities with the use of maps.

The user group assessment was divided into three sections. A first section introduced the participants. The subsequent section was the testing of the application by each of the participants, based on the scenario that was provided. As stated before, the evacuation planning involves several local agencies, hence a scenario was written in an assessment script according to the roles that each participant has in the planning. Each participant was directed to conduct several tasks related to the evacuation process through a software application. The last section of the group assessment was a discussion. During this section all participants had to fill out a post-test questionnaire on the test that had been conducted. After that, a number of predefined questions moderated a group discussion with all the participants. The questions focused on the issues relevant to a local SDI to support evacuation planning. The following table 7-2 shows the agenda of the evaluative assessment.

Table 7-2: Agenda of the user group assessment

Activities	Allocated time (minutes)
Session 1: Introduction	**30**
▪ Opening speech to welcome the participants	5
▪ Presentation of the assessment	25
Session 2: Testing the prototype	**45**
▪ Explanation on testing procedure	10
▪ Participants test the prototype	35
Session 3: Discussion	**70**
▪ Explanation and distribution of post-test questionnaire	5

Table 7-2: ***(continued)***

Activities	Allocated time (minutes)
▪ Participants fill out the questionnaire	10
▪ Group discussion on predefined questions	45
▪ Conclusion	10
Total Time	**2 hours 25 minutes**

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 *Kecamatan* Turi; Hargobinangun and Purwobinangun in *Kecamatan* Pakem; Glagaharjo, Kepuharjo, and Umbulharjo in *Kecamatan* Cangkringan (Dinas P3BA, 2009). From this scenario several tasks were generated for Dinas P3BA and Dinas Kesehatan in accordance to their roles in evacuation planning. Meanwhile, tasks for Bappeda were established based on its role as leading institution in the implementation of local SDI at Sleman Regency. The test scripts which include the tasks for each institution are presented in the table 7-3 below.

Table 7-3: Test script for the participants

A. Test script for Dinas P3BA	
BPPTK has declared "Awas" level of pyroclastic flow in Merapi Volcano. The flow is forecasted going to Hargobinangun and Purwobinangun villages in *Kecamatan* Pakem. Based on data from Dinas P3BA there are 6,122 people lived in the area that need to be transferred to evacuation barrack. Dinas P3BA has duty to inventory numbers of evacuee's lies in evacuation barracks. This information then can be used by other agencies as the basis for allocating facilities and services.	
Task #1	Login to the application by using username: **p3ba** and password: **p3ba**. Then choose session: **evakuasi** with the password: **evakuasi**.
Task #2	Show the location of evacuation barracks which are prepared by Dinas P3BA to accommodate evacuees at Kecamatan Pakem.
Task #3	Add information about numbers of people evacuate to Pakembinangun Barrack at *Kecamatan* Pakem. *Note: for this task it is assumed that there are 325 people evacuate to Pakembinangun Barrack (based on the document of contingency planning).*
B. Test script for Dinas Kesehatan	
BPPTK has declared "Awas" level of pyroclastic flow in Merapi Volcano. The flow is forecasted going to Hargobinangun and Purwobinangun villages in *Kecamatan* Pakem. If this is happening it will cause many people suffer burns injury, respiratory infections, eye disease and also diarrhea. Therefore health facilities and services are needed to serve the evacuees. Based on the information from Dinas P3BA, there are 325 villagers evacuate to Pakembinangun Barrack.	
Task #1	Login to the application by using username: **kesehatan** and password: **kesehatan**. Then choose session: **evakuasi** with the password: **evakuasi**.
Task #2	Show the location of health facilities (*Puskesmas*) at Kecamatan Pakem.
Task #3	Add information about numbers of health services and facilities that will be allocated to Pakembinangun Barrack at *Kecamatan* Pakem.

Table 7-3: *(continued)*

C. Test script for Bappeda	
Bappeda as the leading institution in local SDI implementation has a role to collect spatial data from other local agencies and ensure this spatial data equipped with the metadata. Based on that in this scenario Bappeda is assumed as administrator of the prototype.	
Task #1	Login to the administrator page by using username: **admin** and password: **admin**.
Task #2	In the prototype page, show metadata for villages administrative map
Task #3	Based on analysis it is assumed that Dinas Pol PP & Tibmas has significant role in evacuation planning. Create new user for Dinas Pol PP & Tibnas and assign username: **polpp** with password: **polpp**.

The testing was planned to be conducted in one of the meeting rooms on the fifth floor at Graduate School building of Gadjah Mada University. Logistics, such as notebooks and wireless internet connection, were prepared for the participants, since an internet browser is necessary to test the application. In addition, a video camera and voice recorder was used to record activities and comments of the participants while they test the application. The room setup for the testing session is presented in the figure 7-1 below.

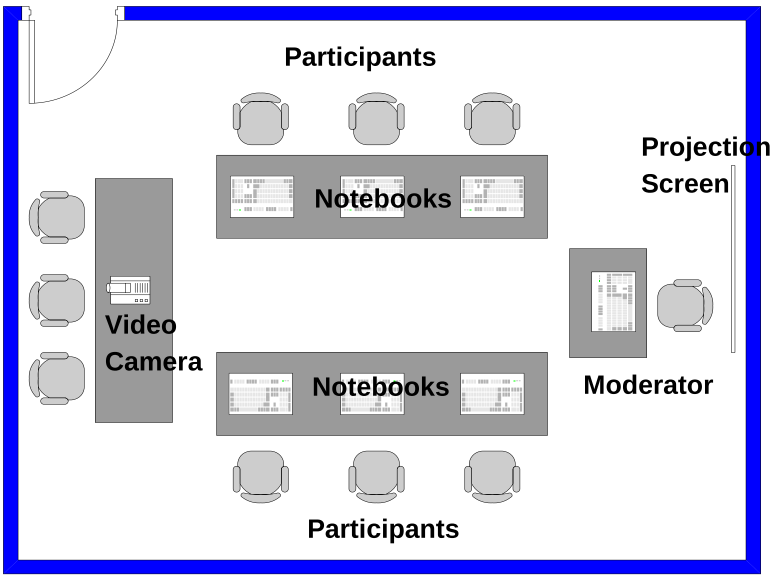


Figure 7-1: Testing room setup

7.2. Evaluation Process

The user group assessment was held on Thursday, 3 December 2009. From the five institutions that had been invited, only three representatives from Dinas P3BA, Dinas Kesehatan and Bappeda came. The assessment started at ten o'clock in the morning and ended at half past twelve in the afternoon.

The assessment was opened by an introductory speech from Dr. Sudibyakto as the program director of the course. Afterwards, a presentation of the evaluation was explained. During the presentation all participants were asked to record all activities in the assessment to be used for research documentation. Crucial issues included:

a. Research background and purpose
b. Purpose and schedule of the user group assessment
c. Definition of local SDI
d. Overview of evacuation planning of Merapi Volcano disaster
e. Overview of the prototype

In the second session representatives from local agencies were trying to perform several tasks synchronously using the prototype. During this session, each participant was accompanied by one note taker who observed how participants performed the tasks. The note taker also had the duty to gather performance data from the testing procedure. Comments from participants while they were working out the task also noted down by the note taker.

Figure 7-2: Testing session

Group discussion session was started once participants finished testing the prototype. First of all they were directed to fill out post-test questionnaire. The main purpose of the written post-test questionnaire is to gather preference information about their opinions and feelings concerning the prototype's usefulness, satisfaction, effectiveness and accessibility. The questionnaire was created using likert scales format which measures participant's level of agreement to a statement regarding usability issues. Statements in the questionnaire were based on evaluation questions as stated in section 7.1. The participants were completed the questionnaire approximately in ten minutes.

After the participants had filled out the questionnaire, the discussion was continued by asking some predefined questions to all participants. These questions had the intention to gather users' recommendations concerning possible improvements for the prototype, and to collect comments about local SDI issues. The four subjects asked were as follows:

1. Is the user list for this prototype appropriate? Who is supposed to be the administrator of the prototype?
2. What other spatial data are required for evacuation planning that was not provided in the prototype?
3. Which features are needed to improve the next prototype?
4. Which aspects of local SDIs are needed to improve the prototype?

Each of the participants was asked the same questions in order to have an elaborate discussion. Most of participants were actively responding to the questions and gave some constructive comments. The session was closed by generating conclusions of what had been achieved in this user group assessment.

7.3. User Feedback

Throughout the test session some user feedback was elicited which addressed important issues for a subsequent improvement. All the three users seemed to understand the task given as they started to explore the application. It was evident that participants were comfortable with maps presentation in the application which utilize *Google Maps* – the reason being that is the zoom control and panning functions could be employed to display objects they were looking for. However one of them remind about the loading time in displaying *Google Maps* which he noticed quite long. This supposed to be related with low internet connection available in the test room.

As the participants worked with the tasks, some comments were put forward regarding their expectations and observations of the usability of the prototype as follow:

- One of the participants highlighted that the label for map tools would be more informative if it was directly stated its function. For example it would be better to give the label name “Add Point Information” instead of “Point Tool”. He reasoned that the alternative provide more clear direction of what user can do with the tool.
- Another issue was the thematic layers provided in the prototype. Most users seemed to have no problems with displaying these layers in the map presentation. They could overlay several maps together and explore the information stored in specific objects. The users considered this capability as a strong point of the prototype, since it facilitates data sharing among data provider, in this case among local government agencies. Nevertheless one of the user noted that the thematic data provided should have good quality in terms of data accuracy. For instance location of a *Puskesmas* in the map presentation should match with the actual

condition in the real world. If it is located at the west side of the road then it would be strange if the map presentation displayed its location on the opposite side.

- A participant made a comment about the user level and administrator role in the prototype. He recommended determining several types of user. It would make the prototype more manageable since he assumed not all users require all the functions provided. One example is that a user might only need to view the map layers and its information without required to add new information to the map. The administrator should arrange this user's privileges.
- Another participant suggested the necessity for chat box/text messenger facility in the prototype. This facility especially needed when each user utilize the application in the same time but at different place. She stated that it can be used to discuss about the information that have been entered into the application. For example if one agency just input information regarding new damaged building and another agency would like to know how severe the damage is, then he/she can directly ask to the user using chat box facility. She realized although there are some text messenger software that can be used for this purpose, such as *Yahoo! Messenger* or *Windows Live Messenger*, it would be superior if this facility is integrated with the prototype.
- One final comment came from a participant who emphasized that the application would be more complete if there is a facility for community participation. He stated that even though the community were not directly involved in evacuation planning, they provide valuable information regarding recent condition in the field such as identification of new damaged buildings. Additionally, they also require information about the location of evacuation infrastructure so they can prepare where to go if the disaster occurred. This point is important note for further research. However this thesis strictly focuses on the use of the application for local government agencies which have significant role in evacuation planning and not as tool for community participation.

7.4. Usability Results

There were two sets of usability data gathered from the user group assessment. The first set was collected from the observation by the note takers while they were accompanying the participants. The second set of usability data was came from the answers to the post-test questionnaire about the usability of the prototype.

7.4.1. Observation data

During the test session note takers were collected performance data i.e. number of errors made on the way users completing the task, percentage of task completed successfully and internet browser used to access the prototype. The first two data were used as part of effectiveness measurement of the prototype while the latter used as part to determined accessibility. The second task of each user represents answer to the evaluation questions number six as stated in Table 7-1, which is successful rate of finding information related to evacuation planning. Meanwhile the third task corresponds with the ability of users to perform specific task for evacuation planning by using the prototype. Observation result for this task provides answer to question number seven of the evaluation inquiries. There are two options of internet browser offered to the participants, namely *Mozilla Firefox* and *Internet Explorer*. According to the survey conducted by NetApplication in the late 2008 (Firman, 2008), these two applications were the most common browser used by the internet users.

Table 7-4: Observation results

Test user	Task completed			Number of errors	Internet browser used
	Task 1	Task 2	Task 3		
Dinas P3BA	Completed	Completed	Completed	0	*Mozilla Firefox* v.3.0
Dinas Kesehatan	Completed	Completed	Completed	0	*Mozilla Firefox* v.3.0
Bappeda	Completed	Completed	Completed	0	*Internet Explorer* v.8

From Table 7-4 it can be noticed that all of the tester were able to finish each task without having an error message. It implies that they were successful in finding information they need and able to perform the particular task given concerning evacuation planning. Another outcome of the observation is that the prototype can be accessed using different internet browsers. However one disparity of the prototype's interface was identified in the login panel, where the username's text box in *Internet Explorer* was not as neat as in *Mozilla Firefox.*

7.4.2. Post-test questionnaire

The questionnaire consisted of ten statements which represent usefulness, effectiveness, satisfaction, and accessibility aspects. Statements 6, 7, 9 and 10 in the questionnaire are related with the usefulness of the prototype to support evacuation planning conducted by local agencies. Measurement of the effectiveness is provided by statements 2, 3 and 5 whereas satisfaction aspect signified by statement 1 and 8. Lastly, opinion of the user regarding accessibility aspect was presented in statement 4. Results of the post-test questionnaire are presented in the following tables.

Table 7-5: Post-test questionnaire results

No.	Statement	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)
1	I feel that the user interface and content of this application is satisfy	33.3	66.7	0	0	0

Table 7-5: ***(continued)***

No.	Statement	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)
2	I don't have any difficulties to login to the application	0	100	0	0	0
3	I was able to explore and interact with the map presentation easily	0	100	0	0	0
4	I found that I can easily access the application through internet	0	100	0	0	0
5	With this application I was able to find spatial data needed for evacuation planning which is provided by other local agencies	0	100	0	0	0
6	I think this application useful to facilitate synchronous information sharing that can be used for evacuation planning	33.3	33.3	33.3	0	0
7	I found that the capabilities in this application to create information on map (annotation) can be utilized to support the evacuation planning	33.3	66.7	0	0	0
8	I was pleased with the metadata supplied in this application since it helps to know information regarding the spatial data	0	66.7	33.3	0	0
9	In my opinion, spatial data provided in this application is appropriate with the requirement of spatial data for evacuation planning	0	100	0	0	0
10	I think this application will help to facilitate coordination among local agencies regarding evacuation planning	0	66.7	33.3	0	0

7.4.3. Analysis

Evaluation of the usefulness

Sum of answer to four statements regarding user's perceptions about the usefulness revealed that 83% of the answers were described user agreement while the rest is still uncertain. All users have the same opinion that spatial data available in the prototype were required to support activities of evacuation planning. They were satisfied with the information embedded in the thematic maps as for example they could find number of population data when they click a village in village administration layer. They were also pleased with the prototype's capability to create 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 provide recent information in term of evacuation process, such as number of evacuees or location of damaged roads. Based on these facts, it can be determined that hypotheses 10 and 12 are valid.

Nonetheless a user still has a doubt concerning usefulness of the prototype in facilitating synchronous information. The reason for this probably because when he was exploring maps presentation, he unable to see information entered by other user. Hesitancy also occurred on the use of the prototype to help coordinate different local agencies in evacuation planning. The user might be assumed that besides an application, coordination also require common understanding of the process and persistent institutional arrangements.

Evaluation of the effectiveness

Dimension of effectiveness of the prototype was gathered from post-test questionnaire and reinforced by the observation data. All of the participants were capable login to the system as they successfully completed their first task. The data from observation which show entire users completed the second task indicates that they were able to do some interaction with the map. This was strengthened by the response to statement 3 which confirm user's agreement concerning their capabilities to explore and interact with the maps presentation. Number of errors rate also designates that the prototype was effective in providing functions which facilitate users to achieve their tasks. Moreover in terms of prototype's feature in providing spatial data required for evacuation planning, 100% of the users were able to find those data which provided by different local agencies.

Evaluation of the satisfaction

Responses to statements 1 in the questionnaire clearly show that all participants were satisfied with the user interface and content of the prototype. It seemed that the interface got well appreciation as indicated by one remark from a user. She was interested with the maps presentation which utilized *Google Maps* and with the layout of the prototype. In fact she believed that the chief of her agency would also be delighted with this application. Consequently, it can be assumed that the first hypothesis is accepted.

In case of the metadata, most users were pleased since it provides valuable information. However one of the participant was uncertain about the statement since the metadata elements was available in English not in Bahasa Indonesia. This note is significant for the improvement of the prototype.

Evaluation of the accessibility

Accessibility was measured by both data collection method. Answer to statement 4 in the questionnaire provides information that 100% of the participants were easily accessed the prototype through internet. This result was strengthened by the observation data which shows users were have no difficulties to access the prototype using different internet browsers. It can be concluded that hypotheses 2 and 5 are valid. One thing to be remembered is the speed of access was depending on the internet connection used by the user. Therefore to optimize this application, local government agencies need to provide good internet facility.

7.5. Discussion Remarks

The purpose of discussion session was to collect user's suggestion concerning the prototype and to talk about issues of local SDI related with the prototype. As stated before, four subjects were asked to the participants. In general each of them was clearly expressed their opinions about the questions and some remarks were documented:

- ☑ In term of the user list proposed for the prototype, all of the participants stated that it is relatively appropriate. However representative from Dinas Kesehatan recommended adding Dinas Pol PP & Tibmas in the user list. He argued that during evacuation process the institution was involved in providing task force to help the inhabitants evacuate to more safe location. Moreover he stated the task force also have significant role in securing the danger area from burglars. Using this prototype information about allocation of the task force could be established as a support for evacuation planning. User from Dinas P3BA also suggested inserting Dinas Pendidikan in the list. She reasoned that from the experience in 2006 a number of schools were used as evacuation barracks. Therefore Dinas Pendidikan should be included since it could provide important information concerning school facilities or suitability of a school to be used as evacuation barrack. The other participants agreed with the suggestions. Regarding who supposed to be the administrator of the prototype, entire users were consented that Bappeda is the one. They thought that Bappeda has responsibility in collecting spatial data from other local agencies and coordinating the implementation of local SDI.
- ☑ The next subject was about other spatial data that should be included in the prototype. One data advised by Dinas P3BA was the position of Early Warning System available at *Kecamatan* Turi, Pakem and Cangkringan. According to her opinion EWS is important as precursor of evacuation. Availability of this data would help Dinas P3BA prepare the evacuation process. Additionally, she also implied to append location of central coordination post at *Kecamatan* Pakem because during the crisis this post is used by Satlak PB to organize the response and relief of Merapi Volcano disaster. Another important suggestion also proposed by representative from Dinas Kesehatan. He stated that location of logistics repositories should also be considered. All this time each local agency has their own storage space at their office and it seems mobilization of the logistics still managed inadequately. Thus to help to arrange and coordinate logistics during evacuation process, information of these warehouse is valuable.

- ☑ In case of enhancement of the prototype for next development, a couple of comments were expressed in addition to the feedback which presented in section 7.3. User from Bappeda stated that in order to provide comprehensive information about evacuation planning for the decision maker, the prototype would be more informative if it was equipped with reporting feature. The report might consist of recapitulation of the annotation in the maps which were inserted by each local agency. With this feature, synchronization of the information will be easily viewed by official at the managerial level. He also emphasized the necessity of a facility that could make the administrator directly add spatial data into the prototype, as for now he can only add users and sessions. The other participants were in agreement with the suggestions.
- ☑ Last question was about issues of local SDI related with the prototype. Representative from Bappeda realized that up till now implementation of a local SDI at Sleman Regency is still in initial phase. Efforts such as single-base map program, compilation of spatial data and construction of regulation draft for the implementation have been started since last year. He stated that some obstacles were identified during this period. One example is the availability of spatial data. Experience from the single-base map program showed that not all spatial data possessed by local agencies were in GIS format. Moreover he implied that inexistence of feature catalogue standard have consequences in lack of consistency of the data. The program found that each institution has developed its own catalogue. In the future he expected to have a national standard regarding feature catalogue. A variety of spatial data accessible at local agencies which use the same standard would make the prototype more superior.

  Representative from Bappeda also mentioned another issue related with implementation of local SDI, specifically commitment from the local agency to involve in such program. He stated that some of the local agencies still have low commitment in supporting activities to develop local SDI. User from Dinas Kesehatan was responded to this issue. He recommended that the regulation should be established as soon as possible in order to encourage the commitment from each agency.

  Another issue discussed in the session is on the subject of metadata. All of the users were having the same opinion about the importance of metadata. Nevertheless they also realized that most of spatial data were not equipped with it. Therefore Bappeda as the leading institution of local SDI implementation is expected to disseminate and socialize the development of metadata to other local agencies. Participant from Dinas Kesehatan argued that the socialization is essential since most of local institutions still have a little knowledge on metadata.

One last remark was raised on the human resource aspect. According to user from Dinas Kesehatan, the fact that not all of spatial data available in GIS format is might be related with the availability of human resource particularly in GIS field. For example if in one institution there is no employee who has knowledge or skill on spatial data production, then it is hard to expect their data could be displayed and analyzed using GIS software. Furthermore he suggested that policy concerning formation of the new employee in each agency should be changed in order to overcome this problem.

7.6. Concluding Remarks

Aim of the evaluation was to measure usability of the prototype in term of its usefulness, effectiveness, satisfaction and accessibility. Additionally a group discussion was included in the assessment with the purpose to elaborate user expectation. 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 representatives from local agencies involved in evacuation planning of Merapi Volcano Disaster, specifically Dinas P3BA and Dinas Kesehatan. Moreover Bappeda which has significant role in the implementation of local SDI was also present. The test consisted of utilization of the application based on specific scenario regarding evacuation planning. 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.

From the observation data it was recorded that all of the participants completed their tasks successfully and they were able to access the prototype using different internet browser. On the subject of usefulness, results of the questionnaire expressed that most of the users were in agreement about the prototype’s ability in helping them to perform tasks for evacuation planning. Furthermore the users found the prototype was reasonably effective as they were able to explore and perform some interactions with the maps presentation. Response from the questionnaire also illustrated their satisfactions with the user interface and content of the prototype.

A couple of hindrances were encountered during the evaluation as follow:

- Number of the respondents were not as many as expected before
- Internet connection was occasionally interrupted when users working with the tasks

Nevertheless, in general the participants have in the same mind regarding the advantage of a local SDI to support the evacuation planning, as they employing the prototype. In order to enhance the implementation of the local SDI, they insisted improving several aspects such as availability and quality of the spatial data, establishment of local regulation and standard, development of metadata, and reinforcement of skilled human resources.

8. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarize research findings and its relationship with the objective of this thesis. Some recommendations on further research will also be stated in the last section.

8.1. Conclusions and Research Findings

The main objective of this research is to design and test an application of a local SDI to support the Merapi volcanic risk management, particularly evacuation planning activity which is conducted by the local government of Sleman Regency. The following paragraphs explain the conclusions associated with the specific research objectives presented in Chapter 1.

Utilization of spatial data in the Merapi volcanic risk management activities conducted by Sleman Government. Risk management is indispensable in order to protect and reduce the impact of Merapi Volcano disaster to the community. 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 highly utilized by the local government. List of the spatial data required in the risk management is presented in Table 4-2.

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.

Functionalities of local SDI required in supporting Merapi volcanic risk management. Results from questionnaire survey showed that despite of spatial data utilization considered as key aspect in the risk management, there are several problems related to spatial data access and sharing in local agencies of Sleman Regency. Development of the local SDI is still in early stages as it was identified based on five primary components namely regulation, institutional arrangements, data, and human resources. 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.

Development of an application of a local SDI for evacuation planning of Merapi Volcano disaster. Through this research it was found that user requirements gathered from questionnaire survey can be translated into visual conceptual model using UML diagrams. List of actors involved in evacuation planning together with their roles is described using a use case diagram. A sequence diagram was delivered to visualize series of actions that can be performed by the user and interactions of the objects in the prototype. In order to implement the application of local SDI, geoportal and geospatial web service technologies were used. 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.

Evaluation of the prototype with associated users. The usability assessment showed in term of usefulness most of the participants believed that the prototype was capable in helping them to perform tasks of evacuation planning. Additionally the users found the prototype was convincingly effective as they were able to explore and perform map interactions. The assessment also described users' satisfactions regarding the content and interface of the prototype. 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. However, some suggestions were also recorded for the next prototype development.

8.2. Recommendations for Future Research

Recommendations for future research are as follows:

- This research is limited on spatial data utilization by local government agencies. Since users of the local SDI are not only from government institutions, further studies should incorporates data from other stakeholders.
- This research is mainly discussed on the technological aspect of a local SDI. Other components, which are significant to local SDI development, are not detailed. Further studies concerning legal, institutional or human resources aspects are required.
- Regarding development of the prototype, an interesting next step will be to enable spatial analysis on top of the map presentation. It will require implementation of other geospatial web services such as OGC WFS, WCS, WPS and integration with the geodatabase of the dataset.
- This research is focused on evacuation planning activities of Merapi Volcano disaster. Studies on other risk management activities or other hazards types will enrich utilization of a local SDI application.

References

Aditya, T. 2008. *A Usable local geospatial data infrastructure for improved public participation and collaborative efforts in enhancing community preparedness and mitigation*. International Conference on Tsunami Warning (ICTW), 12-14 November, Bali, Indonesia.

Aditya, T. and M.-J. Kraak., 2009. Geoportals and the GDI Accessibility. Handbook of Research on Geoinformatics. Information Science Publishing: Hershey, PA. p. 42-50

Antara, 2006. *Perintah Gubernur DIY untuk evakuasi warga belum dilaksanakan.* <http://www.antara.co.id/view/?i=1145711365&c=NAS&s=> [18 Desember 2009]

Asante K.O., Verdin J.P., Crane M.P., Tokar S.A., Rowland J., 2006. *The Role of spatial data infrastructure in the management of natural disasters*. 9th GSDI Conference Proceedings, 6-10 November, Santiago, Chile.

Bakosurtanal, 2007. Standar Nasional Indonesia Bidang (SNI) Informasi Geografi/Geomatika. <http://www.idsn.or.id/index.php?option=com_content&task=view&id=70&Itemid=50> [12 November 2009].

Bakosurtanal, 2008. *Panduan Umum Infrastruktur Data Spasial Nasional (IDSN)*.

Cooper A.K., Hjelmager J., Nielsen A., Rapant P., 2003. *A Description of Spatial Data Infrastructures (SDIs) Using the Unified Modelling Language (UML)*, Proceedings of the 21st International Cartographic Conference, Durban S. Africa.

Crompvoets, J., Bregt, A., Rajabifard, A., Williamson, I., 2004. *Assessing the worldwide developments of national spatial data clearinghouses*. International Journal of Geographical Information Science Vol. 18(7): 665-689.

Crompvoets, J., Bregt, A., Bree, F. d., Oort, P. v., Loenen, B. v., Rajabifard, A., and Williamson, I., 2005. *Worldwide (status, development and) impact assessment of geoportals.* FIG Working Week 2005 and GSDI-8, Cairo, Egypt.

Davis, C. A. J., and F. Fonseca. 2006. *Considerations from the development of a local spatial data infrastructure*. Information Technology for Development 12(4):273–290.

de Montalvo, U.W., 2001. *Strategies for SDI implementation: A survey of national experiences*. 5th Global Spatial Data Infrastructure Conference, Cartagena de Indias, Colombia.

de Vries, W.T.**,** 2006. *Why local spatial data infrastructures SDI's are not just mirror reflections of national SDI objectives: case study of Bekasi, Indonesia*. The electronic journal on information systems in developing countries.

Dinas P3BA, 2004. *Laporan akhir penyusunan basis data dan sistem informasi kawasan rawan bencana Kabupaten Sleman*.

Dinas P3BA, 2007. *Laporan mitigasi erupsi Gunung Merapi tahun 2006.*

Dinas P3BA, 2009. *Rencana kontijensi letusan Gunung Merapi*.

Doyle, A., Reed, C., 2001. *Introduction to OGC Web Services*. OGC White paper.

European Committee (EC), 2007. *Directive 2007/2/EC concerning on Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE),* 14 March 2007.

EM-DAT: Emergency Events Database. Centre for Research on the Epidemiology of Disasters (CRED). <http://www.emdat.be/Database/DisasterList/emdat_display_list.php> [18 May 2009]

Firman, M., 2008. *Pangsa pasar IE tergerus Firefox.* <http://teknologi.vivanews.com/news/read/13480-pangsa_pasar_ie_tergerus_firefox> [8 Desember 2009]

Georgiadou, Y., Puri, S.K., Sahay, S., 2005. *Towards a potential research agenda to guide the implementation of Spatial Data Infrastructures – A case study from India*. International Journal of Geographical information Science, Vol. 19: 1113-1130.

Georgiadou Y., 2006. *SDI ontology and implications for research in the developing world*. International Journal of Spatial Data Infrastructures Research, 2006, Vol. 1, 51-64.

Gong, J., Shi, L., Du, D. de By R.A., 2004. *Technologies and standards on spatial data sharing*. Proceedings of the XXth ISPRS congress : Geo-imagery bridging continents, 12-23 July 2004, Istanbul, Turkey.

Groot, R., McLaughin, J., 2000. *Geospatial data infrastructure: concepts, cases and good practice.* Oxford University Press.

Grus L., Crompvoets J., Bregt A.K., 2007. *Multi-view SDI assessment framework*. International Journal of Spatial Data Infrastructures Research, 2007, Vol. 2, 33-53.

Hadikusumo, 1970. Data kegiatan merapi setelah letusan Januari 1969 sampai akhir tahun 1970, Dinas Vulkanology, Yogyakarta.

Itoh, H., Takahama, J., Takahashi, M., Miyamoto, K. (2000). *Hazard estimation of the possible pyroclastic flow disasters using numerical simulation related to the 1994 activity at Merapi Volcano*. Journal of Volcanology and Geothermal Research Vol. 100(1-4): 503-516.

Kedaulatan Rakyat, 2006. *Hirup abu, banyak warga sesak nafas.* Minggu, 11 Juni 2006.

Kompas, 2005. *Koordinasi masih di atas kertas*. 24 Agustus 2005.

Lavigne, F., Thouret J. C., Voight, B., Suwa, H., Sumaryono, A., (2000). *Lahars at Merapi volcano, Central Java: an overview.* Journal of Volcanology and Geothermal Research Vol. 100(1-4): 423-456.

Majalah e-Indonesia, 2006. *E-Government di Kabupaten Sleman: Fokus ke back office dan pelatihan SDM*. Vol. 1(11), April 2006.

Maguire D.J., and Longley P.A., 2005. *The emergence of geoportals and their role in spatial data infrastructures*. Computer, Environment. and Urban Systems Vol. 29: 3–14.

Mansor, S., Shariah, M.A., Billa, L., Setiawan, I., Jabar, F., 2006. *Spatial technology for natural risk management*. Disaster prevention and management, Vol. 13(5): 364-373.

Mansourian A., Rajabifard A., Valadan Zoej M.J., Williamson I., 2006. *Using SDI and web-based system to facilitate disaster management*. Journal of Computers & Geosciences Vol.32: 303–315.

Masser, I., 2000. *Towards a strategy for geographic information in Europe*. GSDI 5 Conference, 21-24 May 2001, Cartagena, Columbia.

Masser, I., 2005. *GIS Worlds: Creating spatial data infrastructures*. Redlands, ESRI

Molina M., Bayarri S, Vargas R., 2008. *The Andean information system for disaster prevention and relief: A Case study of multi-national open-source SDI*. Free and Open Source Software for Geospatial (FOSS4G) Conference, 29 September – 3 October, Cape Town South Africa.

Muller H., von St. Vith S., 2009. *SDI Implementation at the local administration level of Germany*. FIG Working Week, 3-8 May, Eilat, Israel.

Nebert, D., 2004. *Developing Spatial Data Infrastructures: The SDI Cookbook*, Version 2.0. GSDI-Technical Working Group.

Nedovic-Budic Z., Feeney M.E., Rajabifard A., Williamson I., 2004. *Are SDIs serving the needs of local Planning? Case studies of Victoria, Australia and Illinois, USA.* Computers, Environment and Urban Systems, Vol. 28(4): 329-351.

Newhall, C., Bronto, S., Alloway, B.V., Andreastuti, S., Banks, N.G., Bahar, I., Del Marmol, M.A., Hadisantono, R.D., Holcomb, R.T., McGeehin, J., Miksic, J.N., Rubin, M., Sayudi, S.D., Sukhyar, R., Tilling, R.I., Torley, R., Trimble, D., Wirakusumah, A.D., 2000. *10,000 Years of explosive eruptions at Merapi Volcano, Central Java: Archaeological and modern implications*. Journal of Volcanology and Geothermal Research Vol. 100(1-4): 9–50.

O'Donnell V., Birnbaum D., 2005. *Irish Spatial Data Infrastructure Demonstration, Programme on Flood Management: Final Report*. Coastal & Marine Resources Centre, University College Cork, Ireland.

Open Geospatial Consortium (OGC), 2004. *Geospatial portal reference architecture*.

Pareschi, M. T., Cavarra, L., Favalli M., Giannini, F., Meriggi, A., 2000. *GIS and Volcanic Risk Management*. Natural Hazards Vol. 21(2): 361-379.

Rajabifard A., Binns, A., Masser, I. and Williamson, I., 2006. *The role of sub-national government and the private sector in future spatial data infrastructures*. International Journal of Geographical Information Science Vol. 20(7): 727-741.

Rubin, J., Chisnell, D., 2008. *Handbook of usability testing, second edition*. Wiley Publishing, Indiana.

Smith, K., Petley D. N., 2009. *Environmental hazards: assessing risks and reducing disasters.* Routledge, London.

Technology Indonesia, 2008. *Geoportal ditargetkan pada 2013*. <http://www.technology indonesia.com/news.php?page_mode=detail&id=927> [4 January 2009]

Tupai, R., 2006. *Merapi eruptions fears prompt tentative evacuation*. <http://www.reliefweb.int/ rwarchive/rwb.nsf/db900sid/VBOL-6P2DTR?OpenDocument> [18 Desember 2009]

Turkstra J., Amemiya N., Murgia J., 2003. *Local spatial data infrastructure, Trujillo-Peru*. Habitat International 27: 669–682.

Tsang, C.H.K., Lau C.S.W., Leung Y.K., 2005. *Object-Oriented Technology: from diagram to code with Visual Paradigm for UML*. McGraw-Hill, New Delhi.

van Westen C.J. , Georgiadou P.Y. , 2001. *Spatial data requirements and infrastructure for geologic risk assessment*. Proceedings workshop on natural disaster management, ISPRS Technical Committee VII, Ahmedabad, India.

Voight, B., Constantine E. K., Siswowidjoyo, S., Torley, R., 2000. *Historical eruptions of Merapi Volcano, Central Java, Indonesia*, 1768-1998. Journal of Volcanology and Geothermal Research Vol. 100(1-4): 69-138.

Williamson, I., Rajabifard, A., Feeney, F., 2003. *Developing spatial data infrastructures: From concept to reality*. London: Taylor & Francis.

Yan Z., Du P.J., Zhang H.R., Chen G.L., 2005. *Local spatial data infrastructures for medium sized developing cities in china, taking xuzhou as an example*. ISPRS Workshop on Service and Application of Spatial Data Infrastructure, XXXVI(4/W6), Oct.14-16, Hangzhou, China.

Appendix

Appendix 1. Structured Interview Questions

A. Questions to identify existence of Local Spatial Data Infrastructure at Sleman Regency

1. What are spatial dataset available in Sleman Regency?
   Dataset spasial apa yang dimiliki Pemerintahan Kabupaten Sleman?

2. What are initiatives conducted to develop spatial data infrastructure at Sleman Regency?
   Inisiatif apa yang dilakukan untuk membangun Infrastruktur Data Spasial di Kabupaten Sleman?

3. What is regulation/policy available regarding spatial data infrastructure at Sleman Regency?
   Kebijakan/peraturan apa yang ada di Kabupaten Sleman terkait dengan Infrastruktur Data Spasial?

4. Which agency has responsibility as the network node?
   Instansi manakah yang bertanggung jawab sebagai simpul jaringan di Kabupaten Sleman?

5. How is the data sharing and exchange conducted among local agencies?
   Bagaimana kegiatan berbagi dan tukar guna data spasial dilakukan di Pemerintahan Kabupaten Sleman?

6. What are the problems faced in the data sharing among local agencies?
   Permasalahan apa yang dihadapi dalam berbagi data spasial antar instansi pemerintahan Kabupaten Sleman?

B. Questions to gather information about the Merapi Volcanic risk management activities and institutions/agencies involved, particularly in the evacuation planning

1. What activities of risk management are conducted for Merapi Volcanic hazards?
   Kegiatan manajemen resiko apa yang dilakukan dalam penanggulangan bahaya Gunung Merapi?

2. Which institutions/agencies are involved on those activities? and what is the role of each institution/agency?
   Institusi/Dinas mana yang berperan serta dalam kegiatan tersebut? dan apa peran setiap institusi tersebut?

3. What spatial data are needed and available in conducting Merapi Volcanic risk management?
   Data spatial apa yang dibutuhkan dan tersedia dalam penyusunan manajemen resiko Gunung Merapi?

4. How to formulate evacuation planning of Merapi Volcano hazards?
   Bagaimana cara menyusun perencanaan evakuasi dari bahaya Gunung Merapi?

5. What are the steps of evacuation planning of Merapi Volcano hazards?
   Apakah tahapan yang dilakukan dalam perencanaan evakuasi dari bahaya Gunung Merapi?

6. Which institutions/agencies are involved in the evacuation planning?
   Institusi/Dinas mana yang terlibat dalam perencanaan evakuasi?

7. What are the problems identified in formulating the evacuation plan?
   Permasalahan apa yang dihadapi dalam penyusunan rencana evakuasi?

Appendix 2. Fieldwork Questionnaire

Questionnaire of Spatial Data Availability, Sharing and Requirement in Evacuation Planning of Merapi Volcano

Researcher : Tandang Yuliadi Dwi Putra
MSc. Programme : Geoinformation for Spatial Planning and Risk Management
Research title : A Local Spatial Data Infrastructure to Support the Merapi Risk Management, A Case Study at Sleman Regency
Contact : tandank@gmail.com

Thank you for your time in completing this questionnaire. The result will only be used for scientific research.

Date : _______________

I. Profile of Respondent
(Please fill in the blank)

Name : …………………………………………………………………………….
Name of Agency : …………………………………………………………………………….
Department : …………………………………………………………………………….
Position : …………………………………………………………………………….
Telephone/Email : …………….. /……………………………………………………………

II. Spatial Data Availability
(Please give cross mark (X) to the multiple choices question)

1. Does your department possess any spatial data (for example print out maps and/or digital maps)?
   a. Yes b. No

   If your answer is 'Yes', please specify in the table below.

No.	Spatial Data Theme	Spatial Data Format (*hardcopy*/digital)	Scale	Year
1.				
2.				
3.				
4.				
5.				

2. How did your department own those spatial data?
   a. Self-producing
   b. From other agency (ies)
   c. Other *(please specify)*,

   ____

3. Do those spatial data have the metadata?
   a. Yes b. No

4. Do those spatial data stored in a database?
   a. Yes b. No
5. For what purpose those spatial data are used in your department?
   a. Problem analysis
   b. Instruments in the meeting
   c. Tools for field survey
   d. Other *(please specify)*,

   ____
6. Does your department have a Geographic Information System (GIS)?
   a. Yes b. No
7. Does your department have internet connections?
   a. Yes b. No
8. How many GIS operator are available in your department?
   a. none
   b. 1 – 2 person
   c. 3 – 4 person
   d. more than 4 person

III. Spatial Data Access and Sharing

(Please give cross mark (X) to the multiple choices question)

9. How do you know what spatial data are available at other local agencies?
   a. Through the catalog from each agency
   b. Ask directly to each agency
   c. Other *(please specify)*,

   ____
10. How does your department get spatial data from other local agencies?
    a. Buy it
    b. Through cooperation
    c. Other *(please specify)*,

    ____
11. Do you find any difficulties in accessing spatial data that belongs to other local agencies?
    a. Yes b. No
12. Does your department share spatial data with other local agencies?
    a. Yes b. No

    If your answer is 'Yes', please specify in the table below.

No.	Spatial Data Theme	Agency	Activity
1.			
2.			
3.			
4.			
5.			

13. How is the data sharing conducted?
    a. By giving the print out maps
    b. By giving the digital maps in CD/DVD
    c. By providing online maps that can be accessed through internet
    d. Other *(please specify)*,

    ____

14. What problem did you experienced when you combine your spatial data with the spatial data from other agencies?
    a. Different format (for example your data in ArcView format while others in MapInfo)
    b. Different scale/resolution
    c. When you overlay those data, there are some features/attributes that are not fits
    d. Other *(please specify)*,

    ____

15. Do you think spatial data sharing among local agencies is necessary?
    a. Yes b. No
    Reason:
    ____
    ____
    ____

IV. Spatial Data Requirement in Evacuation Planning of Merapi Volcano

16. What is your agency's role in the evacuation planning of Merapi Volcano disaster?
    Answer:
    ____
    ____
    ____

17. In your opinion, what spatial data are needed to formulate the evacuation planning?

No.	Spatial Data Theme	Agency which own the data
1.		
2.		
3.		
4.		
5.		

18. Do you think all local agencies involved in evacuation planning should be able to access the data through internet/intranet?
    a. Yes b. No
19. In your opinion, what web based services are needed to formulate the evacuation planning? *(Please give cross mark (X) to your answer)*

No.	Services	Agree	Disagree
1.	Data discovery *(provide search and discovery to spatial data)*		

2.	Data visualization *(provide visualization images of the actual spatial data)*		
3.	Interactive maps (provide zoom, pan, identify and measure capabilities)		

20. What kind of spatial data visualization is easy to understand?
    a. Print out maps (for example Rupabumi Indonesia Map)
    b. Digital maps (for example ArcView *shapefile*)
    c. Satellite images (for example Google maps)
    d. Other *(please specify)*,

    ____

21. What are the problems faced in the evacuation planning?
    Answer:

No.	Technical Problems	Non-Technical Problems

Appendix 3. List of Evacuation Barracks at Sleman Regency

No.	Name of Barracks	Village	Subdistrict	Function	Width	Length	Size	Capacity	Facilities	Condition
1	Hargobinangun 1	Hargobinangun	Pakem	Evacuation barracks			150 m^2	300 person	Toilet 2 unit, water source, electricity	In development
2	Hargobinangun 2	Hargobinangun	Pakem	Junior high school (SMPN 2 Pakem)			2.354 m^2	1000 person	Toilet 9 unit, water source, electricity	Good
3	Hargobinangun 3	Hargobinangun	Pakem	Elementary school (SD Purworejo)			672 m^2	500 person	Toilet 1unit, water source, electricity	Good
4	Hargobinangun 4	Hargobinangun	Pakem	Village office	9 m	20 m	215 m^2	300 person	Toilet 4 unit, water source, electricity	Good
5	Purwobinangun 1	Purwobinangun	Pakem	Elementary school (SDN Tawangharjo)	7 m	42 m	294 m^2	360 person	Toilet 20 unit, water source, electricity	10 toilet unit damaged
6	Purwobinangun 2	Purwobinangun	Pakem	Multifunction building (Gedung PKK)	7 m	14 m	98 m^2	50 person	Toilet 2 unit, water source	Roof and ceiling damaged
7	Candibinangun	Candibinangun	Pakem	Multifunction building	7 m	35 m	245 m^2	900 person	Toilet 23 unit, water source, electricity	20 toilet unit damaged
8	Pakembinangun	Pakembinangun	Pakem	Multifunction building	12 m	28 m	336 m^2	300 person	Toilet 5 unit, water source, electricity	Good
9	Girikerto 1	Girikerto	Turi	Multifunction building	8 m	30 m	240 m^2	200 person	Toilet 3 unit, water source, electricity	Good
10	Girikerto 2	Girikerto	Turi	Evacuation barracks				200 person	Toilet 3 unit, water source, electricity	Toilet unmanaged
11	Wonokerto	Wonokerto	Turi	Multifunction building	9 m	22 m	198 m^2	300 person	Toilet 6 unit, water source, electricity	Good
12	Umbulharjo	Umbulharjo	Cangkringan	Village office	8 m	16 m	128 m^2	300 person	Toilet 2 unit, water source, electricity	Good
13	Wukirsari	Wukirsari	Cangkringan	Multifunction building	7 m	42 m	294 m^2	150 person	Toilet 3 unit, water source	Toilet unmanaged

No.	Name of Barracks	Village	Subdistrict	Function	Width	Length	Size	Capacity	Facilities	Condition
14	Kepuharjo 1	Kepuharjo	Cangkringan	Junior high school (SMPN 2 Cangkringan)			2.384 m^2	1500 person	Toilet 10 unit, water source, electricity	Good
15	Kepuharjo 2	Kepuharjo	Cangkringan	Village office	7 m	12 m	84 m^2	100 person	Toilet 2 unit, water source, electricity	Good
16	Kepuharjo 3	Kepuharjo	Cangkringan	Evacuation barracks	12 m	20 m	240 m^2			In development
17	Glagaharjo 1	Glagaharjo	Cangkringan	Village office	8 m	26 m	208 m^2	300 person	Toilet 10 unit, water source, electricity	Good
18	Glagaharjo 2	Glagaharjo	Cangkringan	Multifunction building	12 m	30 m	360 m^2	1000 person	Toilet 1 unit, water source	Good
19	Argomulyo	Argomulyo	Cangkringan	Village office	7 m	42 m	294 m^2	300 person	Toilet 1 unit, water source, electricity	Good
20	Merdikorejo	Merdikorejo	Tempel	Multifunction building	7 m	36 m	252 m^2	166 person	Toilet 2 unit, water source	Good
21	Lumbungrejo	Lumbungrejo	Tempel	Village office	13 m	25 m	325 m^2	400 person	Toilet 1 unit, water source, electricity	Good
22	Pondokrejo	Pondokrejo	Tempel	Village office	7 m	12 m	84 m^2	100 person	Toilet 2 unit, water source, electricity	Good
23	Sumberejo	Sumberejo	Tempel	Multifunction building	10 m	25 m	250 m^2	250 person	Toilet 3 unit, water source, electricity	In development
24	Banyurejo	Banyurejo	Tempel	Puskesmas	7 m	15 m	105 m^2	150 person	Toilet 2 unit, water source, electricity	Good

Appendix 4. Example of GetCapabilities XML file


```
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 <!ELEMENT VendorSpecificCapabilities EMPTY>
 ]>  <!-- end of DOCTYPE declaration -->

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<!-- MapServer version 5.0.2 OUTPUT=GIF OUTPUT=PNG OUTPUT=JPEG OUTPUT=WBMP OUTPUT=PDF OUTPUT=SWF
OUTPUT=SVG SUPPORTS=PROJ SUPPORTS=AGG SUPPORTS=FREETYPE SUPPORTS=WMS_SERVER
SUPPORTS=WMS_CLIENT SUPPORTS=WFS_SERVER SUPPORTS=WFS_CLIENT SUPPORTS=WCS_SERVER
SUPPORTS=SOS_SERVER SUPPORTS=FASTCGI SUPPORTS=THREADS SUPPORTS=GEOS INPUT=JPEG INPUT=POSTGIS
INPUT=OGR INPUT=GDAL INPUT=SHAPEFILE -->

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bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/>
  <ContactInformation>
  </ContactInformation>
</Service>

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      <DCPType>
        <HTTP>
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bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Post>
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```
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     </HTTP>
    </DCPType>
   </GetMap>
   <GetFeatureInfo>
    <Format>text/plain</Format>
    <Format>application/vnd.ogc.gml</Format>
    <DCPType>
     <HTTP>
      <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Get>
      <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Post>
     </HTTP>
    </DCPType>
   </GetFeatureInfo>
   <DescribeLayer>
    <Format>text/xml</Format>
    <DCPType>
     <HTTP>
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      <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Post>
     </HTTP>
    </DCPType>
   </DescribeLayer>
   <GetLegendGraphic>
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    <Format>image/png</Format>
    <Format>image/png; mode=24bit</Format>
    <Format>image/jpeg</Format>
    <Format>image/wbmp</Format>
    <DCPType>
     <HTTP>
      <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Get>
      <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Post>
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    </DCPType>
   </GetLegendGraphic>
   <GetStyles>
    <Format>text/xml</Format>
    <DCPType>
     <HTTP>
      <Get><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Get>
      <Post><OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink" xlink:href="http://localhost/cgi-bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;"/></Post>
     </HTTP>
    </DCPType>
```

```xml
    </GetStyles>
  </Request>
  <Exception>
    <Format>application/vnd.ogc.se_xml</Format>
    <Format>application/vnd.ogc.se_inimage</Format>
    <Format>application/vnd.ogc.se_blank</Format>
  </Exception>
  <VendorSpecificCapabilities />
  <UserDefinedSymbolization SupportSLD="1" UserLayer="0" UserStyle="1" RemoteWFS="0"/>
  <Layer>
    <Name>Batas_Kecamatan</Name>
    <Title>Batas Kecamatan Turi, Pakem dan Cangkringan</Title>
    <SRS>EPSG:4326</SRS>
    <LatLonBoundingBox minx="427585" miny="9.14853e+006" maxx="442386" maxy="9.16567e+006" />
    <BoundingBox SRS="EPSG:4326"
            minx="427585" miny="9.14853e+006" maxx="442386" maxy="9.16567e+006" />
    <Layer queryable="0" opaque="0" cascaded="0">
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        <Title>Batas Kecamatan Turi, Pakem dan Cangkringan</Title>
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xlink:href="http://localhost/cgi-
bin/mapserv.exe?map=c:/mapfile_sleman/wms_batas_line.map&amp;mode=map&amp;version=1.1.1&amp;service=W
MS&amp;request=GetLegendGraphic&amp;layer=Batas_Kecamatan&amp;format=image/png"/>
          </LegendURL>
        </Style>
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  </Layer>
</Capability>
</WMT_MS_Capabilities>
```

Appendix 5. Example of KML file


```
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xmlns:kml="http://www.opengis.net/kml/2.2" xmlns:atom="http://www.w3.org/2005/Atom">
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