REMOTE SENSING AND GIS-BASED FLOOD INFORMATION SYSTEM IN MALAYSIA

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ABSTRACT: Flooding is the most common natural disaster in Malaysia. The impact of flooding includes loss of property and residences, destruction of infrastructure and loss of life. In flood disaster management, related data such as inundated areas, location of access roads and evacuation centres from various sources must be centralized and integrated for easily accessible by relevant agencies for fast decision making. As an initiative to assist authorities in flood management in Malaysia, Malaysian Remote Sensing Agency (MRSA) has developed and operationalised the Remote Sensing and GIS-based Flood Information System. The system comprises of four major components which are data entry, data analysis, information retrieval and report generation. The system is developed using JavaScript APIs, PHP, Oracle RDBMS and ArcGIS Server. The main function of the system is to enable users to access information, analyse and generate report as an input in decision making for search and rescue, mitigation, rehabilitation and damage assessment.

1. INTRODUCTION

The most devastating natural disaster experienced in Malaysia is flood. The estimated area vulnerable to flood disaster was approximately 29,800 km^2 or 9% of the total Malaysia area, affecting almost 4.82 million people which is around 22% of the total population (DID, 2009). The 2014 flood that happened from December 2014 to January 2015 was considered to be the worst flood in Malaysia where more than 200,000 people were affected while 21 died (Malay Mail, 2015). The reported damages that was caused by the flood in parts of peninsular Malaysia is expected to have cost the government of Malaysia over RM 1 billion (Berita Harian, 2014). The impact of flooding includes loss of property and residences, damaged agricultural commodities, destruction of infrastructure and loss of life.

The huge losses sustained from floods have stimulated actions to deal with the flood problem as a priority issue. It was believed that the way to increase the efficiency in flood disaster management is to establish a centralized and integrated Geographic Information System (GIS) and Remote Sensing data. The related data such as inundated areas, location of access roads and evacuation centres must be easily and timely accessible by relevant agencies for fast decision making. The amount of loss of lives and properties could be reduced if timely and accurate measure can be taken. In line with this strategy, Malaysian Remote Sensing Agency (MRSA) has developed and operationalized the Flood Information System based on remote sensing, GIS and ICT technologies. GIS is powerful on spatial data management, visualization and spatial analysis while Web-GIS allows users to access flood information timely with visual interaction using web browsers. Remote sensing has capabilities to provide detailed and multi-temporal coverages of flood information through space. The objective of the system is to assist related authorities in flood disaster management in Malaysia. This system will enable the user to access flood-related information, analyse and generate a report as an input in decision making for search and rescue, mitigation, rehabilitation and damage assessment.

This paper will explain the system development process using remote sensing technology, GIS and ICT. The second part of this paper will describe the four major components of the system comprising data entry, data analysis, information retrieval and report generation. The last chapter will give the summary and future development of the system.

2. SYSTEM DEVELOPMENT METHODOLOGY

The development of the system comprises of four phases which are satellite data reception and processing, database design, GIS map preparation and web development. During the data satellite reception and processing phase, Radarsat-2 satellite images are acquired, processed and extracted to produce a spatial layer of the inundated areas. Other spatial data such as land use, access roads, localities, river networks, health center, district boundaries and location of evacuation centres were stored in the database during this stage. Besides that, other non-spatial data such as human population, flood depth, number of flood victims and evacuation centres' information also collected for supporting information.

Using information obtained, an entity relationship diagram was designed to describe the overall relationship of tables and spatial data. In addition, the logical structure is constructed to ensure data is stored in an organized manner. These processes were done during database design.

In the GIS map preparation phase, data retrieved from the database are loaded into ArcMap. Maps were created and saved using ArcMap before they were published via the ArcGIS Server. These maps can be accessed as GIS services so that they can be integrated in the web development phase.

There are five process involved in the web development life cycle which are analysis, design, development, testing and maintenance. In the analysis process, the developer must understand all information and requirement needs by related agencies. Design process, covers activities towards the architecture of the system, function flow diagram and specification of the system. Development is the process focusing on how the design is translated into programming language. After the development process, the system must go through the testing process to make sure the system works properly and functionally. The last process in this life cycle is maintenance process. It includes frequent updating of the system to comply with the requirement of related agencies.

3. SYSTEM ARCHITECTURE

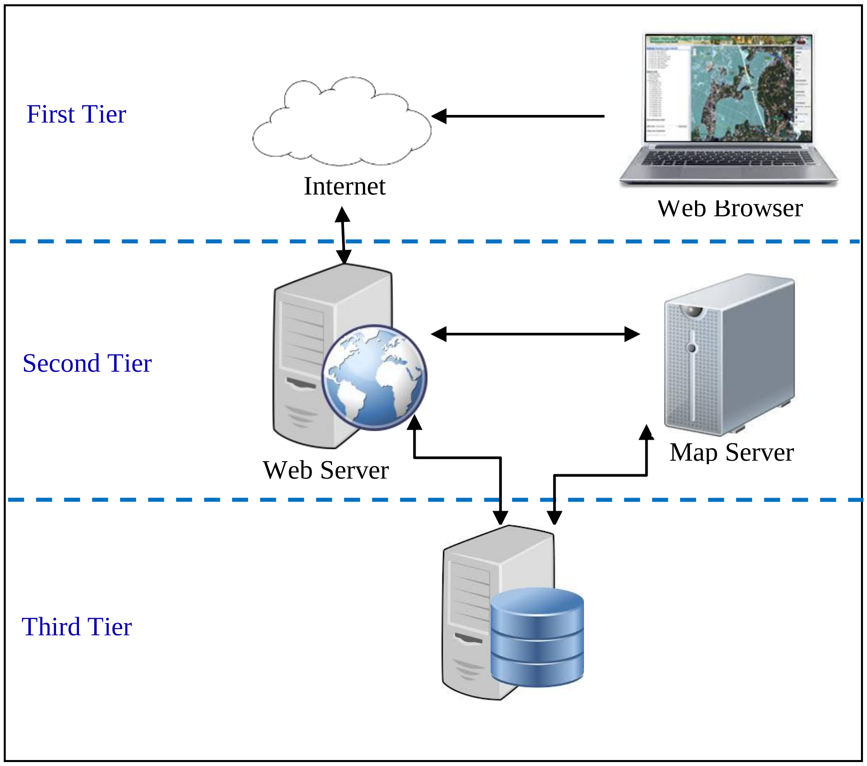
Basically, system structure was built using a three-tier architecture. In the three-tier architecture, the interface or presentation element is located at the client machine, application element at the server machine while data storage element is stored in the database server. The relationship between these three tier is that one tier sends the request to other tier and the other tier responses to the request (Karnatak, 2008).

The first tier is the top level of the system which is the user interface that displays information through the web browser. Web browsers are HTTP clients that send requests and displays responses from the web server. Users are able to access interactive maps and perform basic mapping operations like pan, zoom in/out, identify features, query and print the map display. Besides that the system can also perform data entry, information retrieval and report generation in simple and understandable formats. The user only needs to have a connection to the internet and use web browsers such as Mozilla Firefox, Google Chrome, Opera etc. to access the system.

The second tier is the application layer that includes the web server and map server to bridge the communication between the first tier and the third tier. It will gather and process the request from the client and perform the logic procedure to produce the results, by taking the information from the third tier. Using the Internet Information Services (IIS) as the web browser, information from the database is displayed on the web using PHP, HTML, JavaScript and ArcGIS API for JavaScript. Meanwhile, the ArcGIS Server is used to publish the spatial layers as map services.

The third tier is the data storage tier that manages the data. The data management typically includes storage and retrieval of data, as well as managing updates, providing security, ensuring data integrity, and providing support services such as data backup. These services are provided by a Relational Database Management System (RDBMS) and the data stored in a relational database. In this system, the GIS and non-spatial data are stored in Oracle 11g. The middle tier communicates with the third tier using Structured Query Language (SQL).

Figure 1: The System Architecture of Remote Sensing and GIS-Based Flood Information System



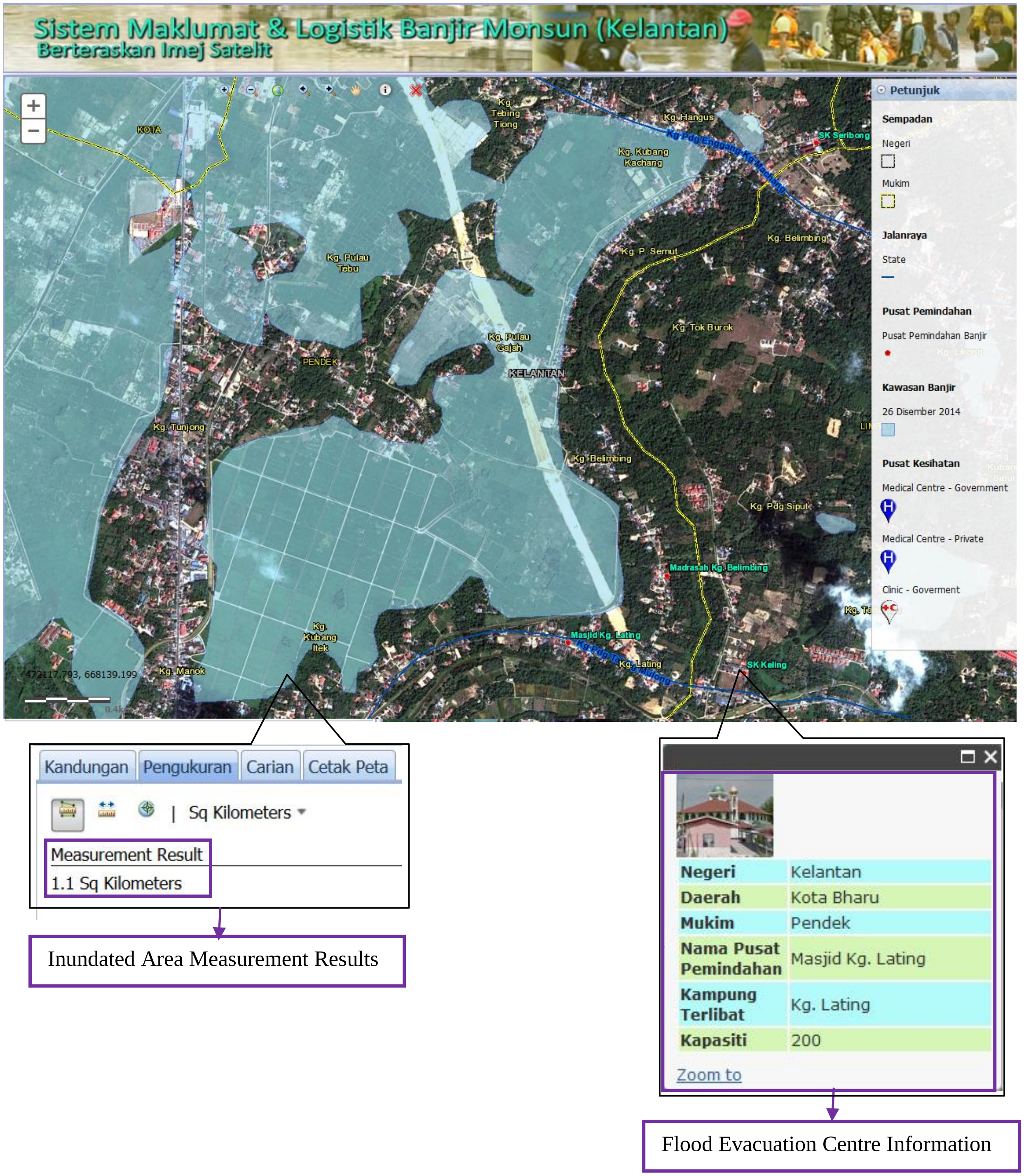
4. OPERATIONAL

The Remote Sensing and GIS-Based Flood Information System is currently used by related authorities in Malaysia. The system access level is controlled with a password protection requirement to provide better control on the usage of the system. Successful logged in user information will be stored in the database as a further reference for the administrator. There are three major web functions, namely monitoring using GIS mapping, data entry and updating data and reporting.

In GIS mapping, the user is able to do basic mapping operations like pan, zoom in/out and identify features. Users can access available data such as geographical boundaries, localities, medical centres location, land use, human population, waterbodies, flood evacuation centres, road networks, river networks, flood inundated areas & Radarsat satellites images. These layers are overlaid with 1.5 meter resolution SPOT-6/7 satellite images for geographical information and interpretation.

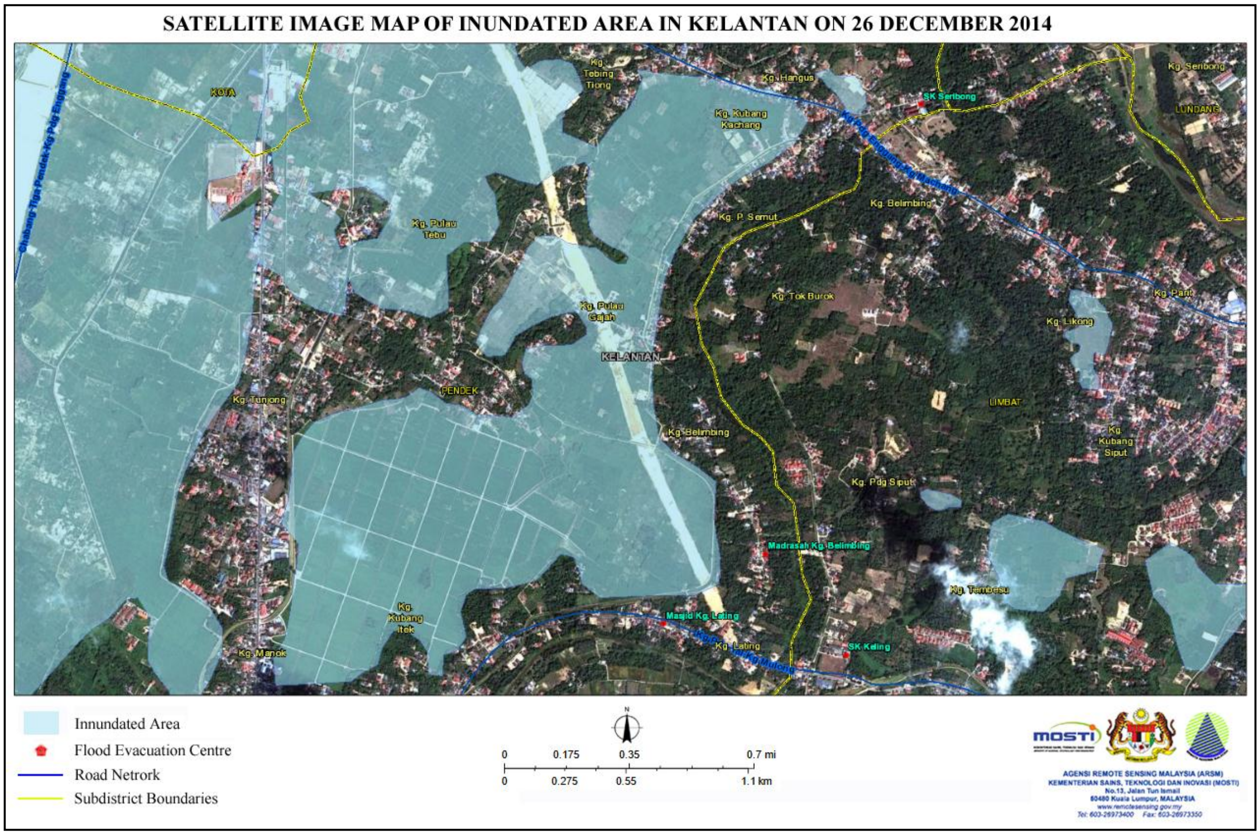
This system adopted the remote sensing capabilities of multi-temporal and large coverage image acquisition to map flooded areas, thus overcoming the limitations cause by the conventional approach. During a flood event, Radarsat-2 satellite images data are acquired, processed and extracted to produce a spatial layer of inundated areas. The integration of this inundated areas spatial layer with other GIS data such as location of access roads and evacuation centres, localities, land use and geographical boundaries helps the authorities perform fast decision making. With GIS, spatial data is stored in a database that can be displayed, querids and manipulated for analysis. The information accessed such as flood affected areas, shortest transportation routes, damages and nearest evacuation centres help authorities in decision making for search and rescue, mitigation, rehabilitation and damage assessment.

Figure 2 : Centralized GIS and Remote Sensing Data



For the ease of input in decision making process, discussion and presentation by the user, the system is designed with the capability to produce flood maps in the PDF format. These flood maps were displayed in the web and are printable in A4 and A3 size. User can easily specify map area of interest and define a customized map to include related data layers.

Figure 3 : Generated Flood Map



This GIS-based system is also capable in performing queries module. This module applies SQL query to a database and the results are displayed in a table view. One of the available analysis is information flood event frequencies within a certain time period for a particular district. Examples of available reports listed in the system are flood dates, affected areas and total number of flood victims.

Figure 4 : Flood event frequency from query module

5. SUMMARY

The implementation of ICT technologies, centralized and integrated GIS and remote sensing data helps to enhance the efficiency of flood disaster management. The information obtained from this system helps related authorities in the decision making process. MRSA continues working to in expand the usage of this system to other agencies as well as upgrading the system to meet current user requirements.

6. ACKNOWLEDMENT

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