III. RESEARCH METHODOLOGY

3.1. Time and Location of Study

This research was conducted from January to May 2006 at Bogor Agricultural University. The location of study is East Java – Indonesia. Geographically, it is located at $7^\circ 12' - 8^\circ 48'\ S\ Longitude\ and\ 111^\circ 0' - 114^\circ 4'\ East\ Latitude$. The northern side is bounded by Java Sea, Eastern part by Bali strait, Southern part by India Ocean and Western part by the province of central Java. The area of East Java is $428.67\ km^2$, coasting of 29 regencies and 9 cities. The location of study can be shown in figure 3.1.

![East Java Indonesia Map](image)

Figure 3.1. Research Location

There are significant number of historical monuments and natural resorts in this area. Photographs of several historical and natural examples also can be seen in the figure 3.2. There are also several holiday resorts lie around this province.
3.2. Web GIS Development Cycle

This system was analyzed and designed based on Web-GIS Development Cycle.

![Web GIS Development Cycle Diagram](image)

Figure 3.3. Web GIS Development Cycle (Alesheikh & Helali 2001)

The Web GIS development cycle is described in terms of eight major activities starting with the requirement analysis and ending with on-going use and maintenance of the Web GIS system.
Step 1. Requirement Analysis

The objective of this study is to build a Web based GIS in order to disseminate spatial and non-spatial tourism information via Internet.

Step 1.1. User Identification

There are two categories of user: tourist and manager.

- Tourist wants to know information of interested objects in order to make good planning and preparing for visit.
- Manager needs to know information of tourist area in order to make good service.

Step 1.2. User Needs

What needs of uses can be shown as questionnaire list below:

<table>
<thead>
<tr>
<th>Tourism</th>
<th>Manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Where is the city, state or country located?</td>
<td>- Where are areas that tourists are interested in?</td>
</tr>
<tr>
<td>- What is the climate? It has warm or cold weather?</td>
<td>- What are the physical-geographic Characteristics of those areas?</td>
</tr>
<tr>
<td>- When is the best time of year to visit?</td>
<td>- What are the demographic and socio-economic characteristics of the local population of each tourist space?</td>
</tr>
<tr>
<td>- Where are the hotels and guesthouse in the city located? What is their classification?</td>
<td>- What infrastructure services are in current and potential tourism areas?</td>
</tr>
<tr>
<td>- What kinds of public transportation are available?</td>
<td></td>
</tr>
<tr>
<td>- Where are the cultural/natural showing located?</td>
<td></td>
</tr>
</tbody>
</table>
Step 1.3. Required Data

There are two types of data used in this research: Non-spatial tourism data, spatial tourism data.

<table>
<thead>
<tr>
<th>Non-spatial tourism data</th>
<th>Spatial tourism data</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Description about tourism object</td>
<td>- Road digital map</td>
</tr>
<tr>
<td>- Information about climate, traditional activity, natural landscape, etc.</td>
<td>- Administrative boundary digital map</td>
</tr>
<tr>
<td>- Information about infrastructure in tourism area such as hotels, restaurants, sights, event location, museums, public transportation, banks, police station etc;</td>
<td>- Tourism object digital map.</td>
</tr>
<tr>
<td></td>
<td>- Infrastructure digital map (location of bank, hotel, shopping center, national park, souvenir etc).</td>
</tr>
</tbody>
</table>

This data was provided by Atlas Center - Bakosutarnal, 2005
Based map scale 1-500000

Table 3.2. Required Data

Step 2. Conceptual Design

Once the required data has been identified, the data model that identifies entities and their relationships were designed. Since, the data will be delivered through a central server, and client will have access to interactive map.
In the architectural system of Web GIS, this service is similar to the client/server architecture of the Web. The geo-processing is broken down into a server-side and client-side task.

A client typically is a Web browser. The server-side consists of a Web server and a Web GIS software programming. The client requests a map or some geo-processing over the Web from the remote server. The server translates the request into an internal code and invokes the GIS functions by passing on the request to the Web GIS software. The software returns the result that is reformatted for interpretation by the client browser application itself or with additional functionality from a plug-in or Java applet. The server then returns the result to the client for display, or sends data and analysis tools to the client for use on the client-side.

The interface consists of WWW pages with HTML forms, which interact with the WWW server through CGI requests. Tourists will stay in this side and send request to server to get information. This requires all functionality to reside at the server.

**Web Server and Data Server** Internet serve is software, which contains a series of programs, which provide GIS functionality to users over the Internet. Data server is used to store data. It can be updated and secure (Finley et al., 1998).
A **map server** is a component that generates maps, fulfills spatial queries, and delivers symbolized maps. A client based on the user's request. The map server can be split into smaller parts to provide specific services. The output of the map server can be in one of three forms: a simple map image (GIF, JPEG etc); a graphic element map or a map composition comprising one or more overlays with predefined colors, styles, legends, and so on; a filtered raster and/or vector data in a form that can be manipulated (query, pan, zoom) on the client.

**Step 3. Hardware and Software Survey**

The purpose of this phase is to focus on the hardware and software components of the system and how to acquire information on what is available. Selecting suitable software is an important step in a successful implementation. Software was evaluated on functionality and performance, and dependent on hardware and operating system. Doing rapid survey in several available Web GIS softwares can be shown as table below.

<table>
<thead>
<tr>
<th>Web GIS Software</th>
<th>Platform of IMS</th>
<th>Browser plug-in</th>
<th>Data format</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcView IMS 1.0a (ESRI)</td>
<td>Unix, Win9x, NT</td>
<td>Applet</td>
<td>Shapefile, Coverage, SDE layer</td>
<td>Commerce</td>
</tr>
<tr>
<td>MapObjects IMS 2.0 (ESRI)</td>
<td>Win9x, NT</td>
<td>Applet</td>
<td>Shapefile, Coverage, SDE layer</td>
<td>Commerce</td>
</tr>
<tr>
<td>Arc IMS 3.1 (ESRI)</td>
<td>Win9x, NT</td>
<td>Applet</td>
<td>Shapefile, Coverage, SDE layer</td>
<td>Commerce</td>
</tr>
</tbody>
</table>
According to table 3.3, all Web-GIS packets can fulfill the research requirements but almost packets are commercial. Only MapServer, which is developed by University of Minnesota is free and open source. Therefore this packet was used in this research functioned for spatial data process.

**Step 3.1. Hardware**

PC Mobile AMD processor 2800+, 512 MB DDR RAM, 40 GB Harddisk.

This computer will be configured both as server and client for testing system.
Step 3.2. Software

This system was developed by using several softwares, which can be shown as table 3.4.

<table>
<thead>
<tr>
<th>No</th>
<th>Software</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoCAD Map 2000i</td>
<td>Preprocessing raw digital data in dxf format. Converting from dxf into shape format.</td>
</tr>
<tr>
<td>2</td>
<td>ArcView GIS 3.3</td>
<td>Viewing and updating attribute data.</td>
</tr>
<tr>
<td>3</td>
<td>Map Server 4.4, PhpMapScript 4.4</td>
<td>Providing functions to deal with spatial data (shape file)</td>
</tr>
<tr>
<td>4</td>
<td>Apache version 2.0.5</td>
<td>Web server.</td>
</tr>
<tr>
<td>5</td>
<td>PHP version 4.3.7</td>
<td>Creating interactive web site by dealing with database and map-server.</td>
</tr>
<tr>
<td>6</td>
<td>Mysql 4.1.9</td>
<td>This is database application software, which is freeware. It used to stored and retrieve all related data. The limitation of this software capability describes on Table 5</td>
</tr>
<tr>
<td>7</td>
<td>PhpMyAdmin 2.6.1</td>
<td>Utility for user interface of Mysql.</td>
</tr>
<tr>
<td>8</td>
<td>Microsoft FrontPage 2000</td>
<td>Designing Web Site Graphical User Interface</td>
</tr>
<tr>
<td>9</td>
<td>MacroMedia Flash MX</td>
<td>Enhancing Web Site graphical user interface</td>
</tr>
<tr>
<td>10</td>
<td>Javascript</td>
<td>Enhance Web Site interface</td>
</tr>
</tbody>
</table>

Table 3.4. Software Requirement
### Table 3.5. Capability of Mysql

<table>
<thead>
<tr>
<th>Operating System</th>
<th>File-size Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linux 2.2-Intel 32 bit</td>
<td>2 GB (LFS:4 GB)</td>
</tr>
<tr>
<td>Linux 2.4</td>
<td>(Using ext3 file system) 4 TB</td>
</tr>
<tr>
<td>Win32 w/FAT/FAT32</td>
<td>2 GB/4 GB</td>
</tr>
<tr>
<td>Win32 w/NTFS</td>
<td>2 TB (possible larger)</td>
</tr>
</tbody>
</table>

### Step 4. Database Design and Construction

The primary purpose of this phase of Web GIS development process was to specify how the Web GIS performs the required application. Database design involved defining how graphic will be symbolized (e.g. color, size, symbols, etc), how graphic files will be structured, how non graphic attribute files will be structured, what is the active layer, in what scale shall the layers expose, how GIS products will be presented (e.g. map sheet layouts report format etc), and what management and security restriction will be imposed on file access.

### Step 4.1. Non-Spatial Database Design

Non-spatial database design proceeds through the steps illustrated in Figure 3.5.

![Figure 3.5. Non-Spatial Database Design Step (Hawryszykiewycz - 1991)](image-url)
The first step is independent of the kind of DBMS used. This step converts
the conceptual E-R to a set of record type, with each record made up a number
of fields. The set of record types is known as the logical record structure (LRT). The
conversion to an LRT is necessary because most commercial DBMS store data as
a set of records. Records are the same fields are defined to be of the same type.
The first step also defines how data in these records is to be used. These access
requirements are used later to choose DBMS structure.

Step 2 and step 3 convert the LRS to a database definition. These steps use
techniques that depend on the DBMS. DBMS - dependent techniques are needed
because different DBMS support different kinds of links between their records.
Database design depends on the structures supported by the DBMS and user
techniques appropriate for these structures.

DBMS-dependent design proceeds in two stages. The first step is logical
design, which defines the DBMS record types and the links between them. The
next step is physical design. This step chooses a physical organization that
supports the methods used to access the database

Non-spatial database contains description about tourism object,
information about infrastructure in tourism area such as hotels, restaurants, sights,
event location, museums, public transportation, banks, police station etc.

**Step 4.1.1. Conceptual Design**

A conceptual model describes the essential semantics of system data. It
consists of a number of symbols joined up according to certain conventions. In
this study we will use relational database model with symbols from a modeling
method known as entity relationship analysis (Chen - 1976). Relational database model stores data as a set of table or relation.

Entity relationship analysis uses three major abstractions to describe data.

These are:

- Entity, which are distinct things in the enterprise.
- Relationships, which are meaningful interactions between the objects.
- Attributes, which are the properties of the entities and relationships.

Entity relationship diagram gives a graphic representation to the conceptual model. To create the relationship among entities, the primary key and foreign key is used.

**Step 4.1.2. Logical Design**

Logical design is to convert the logical record structure to a data model supported by the DBMS. The conversion method depends on the type of data model supported by DBMS. In this research the relational database model is used, so in this case we need not even construct a logical record structure. Instead, the relational description of the used data becomes the DBMS data structure and each relation in the used model becomes a DBMS relation. So every entity will become table in DBMS.

**Step 4.1.3. Physical Design**

Physical design follows logical design. The logical record will be placed in physical file. The structure of the physical files is also chosen. One important choice is the file structure to be used to store records of a given record type. The way this is done depends on the particular DBMS. In this research the used DBMS is Mysql.
Step 4.2. Spatial Database Design

Spatial database design consists of a three-step (Elmasri and Navathe - 2000) design process. In the first step, all the available information related to the application is organized, using a high-level conceptual data model. At the conceptual level, the focus is on data types of the application, their relationships and constraints. The Entity Relationship (ER) model is one of the most prevalent of all conceptual design tools.

The second step called the logical data model is related to the actual implementation of the conceptual data model in a commercial DBMS. Data in a commercial database is organized using an implementation model. Examples of implementation model are hierarchical, network, and relational model. The relational model is one of the most widely implemented models in current commercial DBMS. In the relational model, the data types, relationships, and constraints are all modeled as relations.

The third step called the physical data model deals with the nuts and bolts of the actual computer implementation of the database application. Issues related to the storage, indexing and memory management are handled at this level.

Step 4.2.1. Conceptual Design

The purpose of conceptual model is to represent the mini-world in a manner devoid of computer metaphors. The motivation is to separate out the concepts of the application from the implementation detail. Entity relationship is one of the most popular tools for conceptual data model. The ER model integrates seamlessly with the relational data model, which in turn is one of the most prevalent logical models.
In spatial database design, there is one important thing that is needed to consider is this type of spatial object. There are three types of spatial object: point, line, and polygon.

**Step 4.2.2. Logical Design**

The purpose of this step is to convert conceptual design to logical design. Every entity shown on the E-R diagram must be translated to a GIS layer, a relational table(s), or both, as indicated by the information to be included. In addition, every relationship of the type "relationship represented in database" (single line hexagon on the E-R diagram) must be implemented through the primary and secondary keys in the tables for the entities represented.

**Step 4.2.3. Physical Design**

The purpose of this step is to convert logical model to physical model with specific SDMB. In this research, physical model will be stored in Shape file format (ESRI).

**Step 5. Acquisition of GIS Software and Hardware**

GIS hardware and software acquisition includes the final selection of the hardware and software (by competitive bid in response to a request for proposals - RFP, as necessary); the delivery and installation of the hardware and software; and all necessary renovation of space, wiring, and environmental remodeling.

**Step 6. Web GIS System Integration**

At this step of Web GIS development cycle, the hardware and software have been acquired and database is completed. The aim of this step is to integrate different components of hardware and software to test and make sure it works as
expected. GIS System Integration is bringing the final database and the hardware and software together and testing their combined operation.

**Step 7. Application Development**

Web GIS application development is preparing applications identified in the needs assessment, which require additional programming using the GIS macro language or other supporting programming languages. By using this hardware and software component in this previous list, the system will be implemented.

**Step 8. Web GIS Use and Maintenance**

Web GIS use and maintenance is starting use of the GIS and institution of database, hardware and software maintenance programs. Further application development and user training are also continuing needs.