# DETERMINATION OF MOUNTAIN CAPACITY EVACUATION PATH USING ANT COLONY METHOD WITH GIS APPROACH IN VULANOLOGY CENTER AND GEOLOGY MITIGATION

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## ABSTRAK

Mount Tangkuban Perahu is one of the active volcanoes in Indonesia, located in Subang, Bandung, West Java Province. The peak is in the coordinate position 107.633 east longitude; 6,773 south latitude with a height reaching 2084 meters above sea level. So far the Volcanology and Mitigation and Disaster Center has 9 evacuation routes in the Cikole Village area, but 5 of the routes do not fulfill their proper functions, which are located in Ciater Subdistrict, Cagak Road, Serang Panjang, Sagala Herang and Cijambe. These pathways are difficult to evaluate. because it has road access that is blocked by lava. The important thing to do is to do disaster mitigation which is an effort to reduce risk. Based on the problems described earlier, the Bandung City PVMBG needs a Geographic Information System that can map or present disaster Tangkuban Perahu data and information so that the disaster area and the location of the evacuation posts and evacuation routes can be known easily, where this system uses the ant colony method to determine the path nearest evacuation.
Keywords: Evacuation Route, Disaster Mitigation, Geographic Information System, Evacuation Post Location, Lembang.

## 1. INTRODUCTION

Mount Tangkuban Perahu is one of the active volcanoes in Indonesia, located in Subang, Bandung, West Java Province. The peak is in the coordinate position 107.633 east longitude; 6,773 south latitude with a height reaching 2084 meters above sea level. On July 26, 2019 at 15:48 WIB there was an eruption of the Tangkuban Perahu Volcano. Monitoring is carried out one of them through the Volcano Observation Post (Pos PGA) located in Wates, Cikole Village, Lembang District. So far the Volcanology and Mitigation and Disaster Center has 9 evacuation routes in the Cikole Village area, but 5 of the routes do not fulfill their proper functions, which are located in Ciater Subdistrict, Cagak Road, Serang Panjang, Sagala Herang and Cijambe. These pathways are difficult to evaluate. because it has road access that is blocked by lava. The important thing to do is to do disaster mitigation which is an effort to reduce the risk of natural disasters, human-made disasters or a combination of both, through physical development as well as awareness and increased ability to face the threat of disasters.

Based on interviews with the Head of Volcano Potential Disaster Evaluation Division represented by Mr. Ir. Gede Suantika, M.Si, who is the Head of Evacuation. stated that when mitigating volcanic eruption efforts at the Center for Volcanology Mitigation and Geological Disasters were carried out at the Mount Tangkuban Perahu observation post to report information on the eruption of the Mount Tangkuban Perahu eruption and continued to be carried out to the alert level level. The land in Lembang Subdistrict is a volcanic area so that the contours in the area may experience changes. This resulted in the determination of evacuation routes often undergoing changes in the route to the evacuation post, when determining the evacuation route in PVMBG in the form of a map depicting evacuation routes that did not specify in each district. This resulted in problems in determining the evacuation route to the evacuation post that was not suitable in the Lembang sub-district area and as a result of the evacuation route going to a further route to the evacuation post. As in July 2019 the depiction of the evacuation route to the evacuation post occurred an error which resulted in the evacuation route being inappropriate. The need for visualization media that can present evacuation routes is by using Geographic Information Systems. Because, by using visualization media in the form of online maps will be easily understood by the Head of Volcano Mitigation and Disaster Section, as well as the public who want to know the disaster area.

Based on the problems described earlier, the Bandung City PVMBG needs a Geographic Information System that can map or present disaster Tangkuban Perahu data and information so that the disaster area and the location of the evacuation posts and evacuation routes can be known easily, where this system uses the ant colony method to determine the path closest evacuation and can help the Head of

Volcano Disaster Mitigation and Preparedness in monitoring the evaluation of disaster-prone areas to support the implementation of disaster management.

### 1.1 Formulation of the problem

Based on the background of the problems that have been described previously, the formulation of the problem that underlies the preparation of this final project is to establish the determination of the Tangkuban Perahu mountain lava evacuation route using the ant colony method with the sig approach at the Center for Volcanology and Geological Mitigation.

### 1.2 Purpose and objectives

Based on the problems studied, the purpose of this thesis is to establish the Determination of the Tangkuban Perahu Lava Evacuation Path Using the Ant Colony Method With the Sig Approach at the Center for Volcanology and Geological Mitigation. Whereas the purpose of this is to assist the Head of the Volcano Becoming Evaluation Unit in determining the evacuation route taken according to the level of disaster in disaster prone areas in Tangkuban Perahu Mountain.

## 2. RESEARCH CONTENTS

### 2.1 Language and tools used

The language and tools used in building WebSIG are:

a) The application is built using HTML, PHP, JavaScript, CSS, GoogleApi programming languages.
b) Data Base Management System (DBMS) uses Postgresql
c) For creating layers using ArcGIS.

The scope of a study must be limited so that the research is directed according to its purpose. The limitations of the problem in this study include:

1. Spatial data on the map includes areas of disaster-prone areas in the form of polygons, District areas in the form of polygons, Village areas in the form of polygons, locations of refugee posts in the form of points, evacuation routes in the form of polylines.
2. Non-spatial data includes population data.
3. Case studies are based on data provided by the Bandung City PVMBG.
4. Layers used:
   a. Village boundary layer, explains the village boundaries in Garut Regency
   b. Disaster event layer that explains how many disaster events have occurred.
   c. Population density layer which explains the population density of each village.
   d. Disaster risk layer that explains the level of disaster risk in each village.
5. Online web-based applications (WebSIG).

### 2.2 Analysis System

Analysis of the ongoing system is one of the stages to find out the system that is running on PVMBG which will be associated with conformity in system development. Analysis of the system that is currently running in PVMBG, including procedures for determining KRB including.

KRB procedure is a procedure where the disaster prone area is based on where the position is. The processes carried out are :

1. Investigate mapping in areas prone to disaster.
2. Monitoring volcanoes in outline using seismic, deformation, geochemical, and other geophysical methods.
3. Potential for volcanic eruption according to ESDM regulation No. 11 of 2006
4. Map of Disaster Prone Areas.

The evacuation route for the community is a procedure where the evacuation route for the community. The processes carried out are:

1. The Volcano Observation Post provides information on volcano eruption to officers in the field of evaluation of potential disasters.
2. Officers in the field of evaluation of potential disasters receive reports of volcanic eruptions
3. The Disaster Potential Evaluation Officer sounds an early warning sign of an eruption of a volcanic eruption.
4. The community receives an early warning sign of volcanic eruption from the Disaster Potential Evaluation Officer.
5. The Disaster Potential Evaluation Officer checks the evacuation route.
6. If the evacuation route can be traversed by the community, then an evacuation route sign is made.
7. If there is no evacuation route, installation of signs for evacuation routes will not be made.
8. Disaster Evaluation Potential Officer makes and installs evacuation route
9. Community Go to the evacuation place when it has been ordered by the authorities.

Procedure for determining the refuge post is a procedure whereby determining the refuge post is based on where the position is. The processes carried out are:

1. The Volcano Observation Post provides information on volcano eruption to officers in the field of evaluation of potential disasters
2. Officers in the field of evaluation of potential disasters receive reports of volcanic eruptions
3. Officers in the field of potential disaster evaluation see whether reports of volcanic eruptions are at a serious level to be handled.
4. If the volcano eruption is in a serious level to be handled immediately, the Officer in the field of potential disaster evaluation provides

information on volcanic eruption to the Head of the Volcano Disaster Mitigation Section.
5. The Head of the Volcano Disaster Mitigation Division receives reports of volcanic eruptions.
6. The Head of the Volcano Disaster Mitigation Section sees whether the eruption of the volcano must be assigned a hazard status on a national scale.
7. If the volcano eruption is dangerous, the Head of the Volcano Disaster Mitigation Section proposes to the president of the Republic of Indonesia.
8. If the President of the Republic of Indonesia determines that a volcanic eruption is dangerous, then a national hazard status is created.

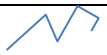
Jika sudah di tetapkan oleh pr esiden RI status bahaya erupsi gunung api tersebut maka petugas bidang evaluasi potensi bencana membuat peta KRB dan dibuatnya pos pengungsian berdasarkan radius peta KRB

### 2.3 Analysis Data Spatial

Spatial data on applications that will be built include sub-districts, villages, KRB, evacuation posts and pathways. The spatial data is distinguished by different shapes and colors so that the information displayed looks clearer

The following specifications of spatial data information on the application to be built that can be seen in Tabel 1.

**Tabel 1.** Analisa Data spasial

| No | Indikator | Data Spasial | Contoh |
|---|---|---|---|
| **1** | KRB | Polygon |  |
| **2** | KRB II | Polygon |  |
| **3** | KRB III | Polygon |  |
| **4** | Kecamatan | Polygon |  |
| **5** | Kelurahan | Polygon |  |
| **6** | Pos pengungsian | Point |  |
| **7** | Jalur Evakuasi | Line |  |

### 2.4 Analysis Data Non Spatial

Non-spatial data (attribute) is individual information from each digital map vector data, non-spatial data is needed in this GIS, which will contain information about spatial data. Analysis of non spatial data used to build this system can be seen in Table 2.

**Tabel 2.** Analisa Data non spasial

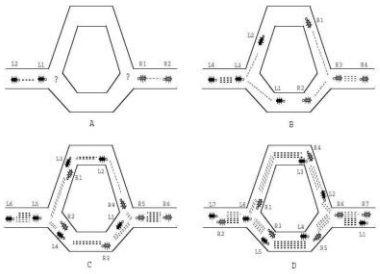
| No | Nama | Deskripsi | Atribut |
|---|---|---|---|
| 1 | Data Kependudukan | Berisi mengenai informasi data kependudukan di Kecamatan lembang. | Nama_desa, Jumlah Penduduk |

Whereas spatial data entities are polygons that contain data about areas in a map. This research does not discuss teristik data because the software is built using google maps which has integrated teristik data ready to be used for various purposes. The relation of data between attribute data and spatial data can be seen in Figure 1 in the attachment section.

### 2.5 Penentuan jalur evakuasi menggunakan metode ant colony

Disaster area is an area that must be evacuated, where victims must be evacuated quickly, so that evacuation victims are dealt with quickly by determining the nearest evacuation route, then one of the approaches makes calculations using the ant colony method. Where in that case the Cikole village area was the priority area for evacuation to the refugee post. Following are the steps for calculating the shortest route using the ant algorithm. The stages used are:

1. Intensity of ant trail between villages and their changes (τij).
2. Many villages (n) including coordinates (x, y) or distance between villages (dij) and departing villages and destination villages.
3. The ant-cycle constant (Q).
4. The control set of ant trail intensity (α), value $\alpha \geq 0$.
5. Visibility control constant (β), value $\beta \geq 0$.
6. Inter-village visibility = 1 / dij (ηij).
7. Lots of ants (m).
8. The ant trail evaporation constant (ρ), the value of ρ must be> 0 and <1 to prevent an infinite pheromone trace.
9. The maximum number of cycles (NCmax) is fixed throughout the algorithm, while τij will always be updated for each cycle of the algorithm starting from the first cycle (NC = 1) until the maximum number of cycles (NC = NCmax) or convergence occurs.



**Gambar 1.** Metode Ant Colony

The following is a table of visibility between villages.

**Tabel 3.** Visibilities inter village

| Village ke | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 200m | 600m | 1200m |
| 2 | 400m | 0 | 550m | 700m |
| 3 | 2400m | 3000m | 0 | 1500m |
| 4 | 800m | 650m | 350m | 0 |

Measurement of distances between villages is calculated by Google Maps. Distance data between locations can be seen in the table.Information :

1. Jalan Jayagiri, Jalan Gunung Putri, Cilumber Street
2. Jalan Cibedug, Jalan Raya Tangkuban Perahu, Jalan Cilumber
3. Jalan Lembang Genteng, Jalan Raya Tangkuban Perahu, Jalan Cilumber
4. Jalan Tangkuban Perahu, Jalan Cibedug, Jalan Cilumber

**Tabel 4.** Feromon Antar Titik

| Village ke- | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0,01 | 0,01 | 0,01 |
| 2 | 0,01 | 0 | 0,01 | 0,01 |
| 3 | 0,01 | 0,01 | 0 | 0,01 |
| 4 | 0,01 | 0,01 | 0,01 | 0 |

The value of the visibility parameter (η) and pheromone intensity (τ) will later be used in the probability equation and is a parameter that affects the ants in the selection of the next point (transition rule). Refresh the destination point by calculating probability:

$$\Sigma = [\tau(r,u)]\ \alpha \cdot [\eta(r,u)]\beta = \quad \ldots\ldots(1)$$

**2.6 Implements System**

After an analysis and design of the software to be built, the next step is to implement these results. This software was built using software with specifications can be seen in table 5.

**Tabel 5.** Perangkat lunak yang ada saat ini

| | | |
|---|---|---|
| 1. | Sistem Operasi | Microsoft Windows 7 |
| 2. | Aplikasi Perangkat Kerja | Microsoft Office 2010 |
| 3. | Web Browser | Google Chrome |
| 4. | ArcGis Dekstop | Versi 10.4 |
| 5. | PostgreSQL Database | Versi 4 |

The initial step in implementing the system is implementing the database. In accordance with the results of the design, 6 tables were made using PostgreSQL DBMS. The results of database implementation can be seen in table 6.

**Tabel 6**. Hasil Implementasi basis data

| No. | Name File | File yang berhubungan |
|---|---|---|
| 1 | Admin | Admin.sql |
| 2 | Kecamatan | Kecamatan.sql |
| 3 | Kelurahan | Kelurahan.sql |
| 4 | User | Users.sql |
| 5 | Petugas | Petugas.sql |
| 6 | Pos pengungsian | Pos_pt.sql |
| 7 | KRB | Batas_ar.sql |
| 8 | Kepala | Kepala.sql |

The next step is to implement the interface in accordance with the results of the design. The results of the interface implementation are divided into two types, namely the admin interface implementation and the interface implementation The results of the admin interface implementation can be seen in table7.

**Tabel 7**. Hasil Implementasi Antar Muka

| No. | Menu | Nama File |
|---|---|---|
| 1 | Login | Login.php<br>Style.css |
| 2 | Beranda | index.php<br>Style.css |
| 3 | Pengolahan data Kecamatan | kecamatan.php<br>Style.css |
| 4 | Pengolahan data Kelurahan | Kelurahan.php<br>Style.css |
| 5 | Pengolahan data user | User.php<br>Style.css |
| 6 | Pengolahan data Pos pengungsian | pos.php<br>Style.css |
| 7 | Pengolahan data KRB | KRB.php<br>Style.css |
| 8 | Logout | Logout.php |

| | | |
|---|---|---|
| | | Style.css |

The result of the implementation of a very significant interface in the development of geographic information system software is the interface that displays the geographical data of Mount Tangkuban Parahu along with the public facilities that are in it.

**Tabel 8.** Kebutuhan fungsional perangkat lunak

| No. | Spesifikasi Kebutuhan Fungsional |
|---|---|
| SKPL-P-01 | Sistem dapat menyediakan fasilitas login. |
| SKPL-P-02 | Sistem menampilkan kecamatan dan kelurahan dalam peta Kota Lembang. Peta bisa ditampilkan dalam bentuk *map* dan *satelite*. |
| SKPL-P-03 | Sistem dapat menyediakan pengelolaan data koordinat (spasial) maupun data atribut (non spasial). |
| SKPL-P-04 | Sistem dapat memberikan status Kawasan Rawan Bencana |
| SKPL-P-05 | Sistem dapat memberikan informasi lokasi tempat pos pengungsian. |
| SKPL-P-06 | Sistem memiliki informasi jalur evakuasi yang nantinya bisa dimanfaatkan sebagai sarana *feedback* oleh dinas terkait, bidang lain, masyarakat, maupun lainnya. |
| SKPL-P-07 | Sistem bisa melihat pemetaan, status KRB dan letak posisi pos pengungsian |

Tabel 9. **Spesifikasi Kebutuhan Non Fungsional**

| No. | Spesifikasi Kebutuhan Non Fungsional |
|---|---|
| SKPL-S-01 | Sistem ini dibangun berbasis web. |
| SKPL-S-02 | Sistem harus bisa diakses dari sistem operasi Windows, Linux, maupun Mac OS (*multiplatform*). |
| SKPL-S-03 | Sistem ini nantinya dipakai oleh kepala sub bidang evaluasi yang berperan menentukan jalur evakuasi |
| SKPL-S-04 | Link-link di dalam aplikasi yang berhubungan dengan pengolahan data harus melalui proses login yang legal sehingga tidak diijinkan mengakses link tanpa melalui tahapan yang benar. |
| SKPL-S-05 | Aplikasi web yang dibangun diharapkan ringan dan mudah diakses. |

**2.5 Pengujian Sistem**

Testing presents an anomaly that is of interest to software engineers. In the software process, the engineer first tries to build software from the concept of abstark to the implementation that can be seen, then testing is done. Engineers create a series of test cases intended to "dismantle" software that has been built. Basically testing is a step in the software engineering process that can be considered (at least psychologically) as destructive rather than constructive.

Black-box testing focuses on the functional requirements of the software. Thus, black-box testing allows software engineers to get a set of input conditions that fully use all functional requirements for the program. Black-box testing tries to find errors in the following categories: [4]

1. Functions that are incorrect or missing,
2. Interface error,
3. Errors in data structures or external database access,
4. Performance error,
5. Initialization and termination errors.

Black-box testing tends to be applied during the final stages of testing, because black-box testing pays attention to the control structure, so attention focuses on the information domain.

## CLOSE

Based on the results that have been achieved in building the Geographic Information System of the Mount Tangkuban Perahu Lava Evacuation Pathway Determination at the Center for Volcanology and Geological Disaster Mitigation, the City still has shortcomings, therefore it is recommended to add things that can complement the future, including:

1. Geographic Information Systems that are built can be developed in features as well as displays that can be made more attractive and the system can be integrated with the systems contained in the Center for Volcanology and Geological Disaster Mitigation.
2. For the development of this application in the future we need a tool to detect lava flow which can then be integrated in this geographic information system.

Thus the advice can be given, hopefully these suggestions can be used as input that can be useful for writers in particular and others who will develop in the future.

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