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To Select Evacuation Route

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Abstract:

Conditions of Earth's plate are thin and divided into pieces cause much natural disasters, such as earthquakes, tsunami and volcano eruption. Every nation's government must provides services for public safety, especially for people that live in disaster-prone areas. One of those services is provides evacuation route for them. But all this time, the selection of evacuation route is seem does not well organized, it could be seen when a disaster happen there will be many accumulation of people on the steps of evacuation route. This problem will be dangerous to people because hampers evacuation process. By some methods in statistics analysis (association rules and fuzzy hierarchical cluster analysis), authors tries to give a suggestion in how to prepare evacuation route which is organized and based on people habit.

1. Introduction

We have anxiety panic attacks because we are creatures of habit [5].We can say that habit is like a routine work. Habit makes us behave in a similar that habit when we were panic. One of the panic moment that may happens is when a disaster happen, because disaster is threaten lives. Humans often experience anxiety attacks because human beings are accustomed to doing routine things. The habit causes us to behave similarly when we experience a panic. One moment of panic that may occur is when disaster strikes. Based on common practice, then in the face of disaster, people will behave the same as the disaster threatens their safety.

These things happened when Kelud Mountain, Kediri, erupted. Traffic jam occured in main evacuation route, Wates, Kediri, Province of East Java. Officers had difficulty to untie the traffic jam because of the large number of vehicles, does not comparable to existing roads. The traffic jam made people scared. They screamed to call out for help from officers, while hail is happened. Sand and volcanic ash is also fell. On the sky, bright and red storm is happened. Thunder is also heard by all the people [3].

All this time, the selection of evacuation route does not well organized. People is forced as soon as possible to goes to main road, and unfortunately main road is limited especially in developing countries. With that condition, many accumulation of people on the steps of evacuation route when a disaster happen. That will cause occurrence of traffic jam and hamper evacuation process. And of course will endangers people lives.

There are many ways to describe emergency management and the importance purpose is saving lives and property in disasters. Science and technology were applied in planning and managing the extreme events that can injure or kill large numbers of people, do extensive damage to property and disrupt community life [6]. Statistics as a science had been applied in disaster management [7]. This method will use a statistical method to make simulation method in managing the evacuation road for mitigation

when Merapi erupt. One of many Statistics methods is association analysis, which is useful for discovering interesting relationships which is hidden in large data sets. This relationships can be displayed in the form of association rules or sets of frequent items (frequent road passed through by local residents). For illustrative purposes, our discussion of association rules will be represented in the term of market transaction.

Let $I = \{i_1, i_2, ..., i_d\}$ be the set of all items in a market transaction data and $T = \{t_1, t_2, ..., t_N\}$ be the set of all transactions recorded in database. Each transaction t_i contains a subset of items which is chosen from I. In association analysis method, a set of zero or more items is termed an itemset. The transaction width is defined as the number of items present in a transaction. A transaction t_j is said to contain an itemset X if X is a subset of t_j. An important property of an itemset is its support count, which refers to the number of transactions that contain a particular itemset. Mathematically, the support count, $s(X)$, for an itemset X can be stated as follows:

$$s(X) = |\{t_i \mid X \subseteq t_i, t_i \in T\}|, \quad (1.1)$$

where the symbol $|\ .\ |$ denote the number of elements in a set. An association rule is an implication expression of the form $X \rightarrow Y$, where X and Y are disjoint itemsets. The strength of an association rule can be measured in terms of its support and confidence. Support determines how often a rule is applicable to a given data set, while confidence determines how frequently items in Y appear in transactions that contain X. The formal definition of these metrics are:

$$\text{Support, } S(X \rightarrow Y) = s(X \cup Y) / N \quad (1.2)$$

$$\text{Confidence, } C(X \rightarrow Y) = s(X \cup Y) / s(X) \quad (1.3)$$

Support is an important measure because a rule that has very low support may occur simply by chance. A low support rule is also likely to be uninteresting from a business perspective because customers seldom buy together. Support is often used to eliminate uninteresting rules. Support also has a desirable property that can be exploited for the efficient discovery of association rules. Confidence, on the other hand, measures the reliability of the inference made by a rule. For a given rule $X \rightarrow Y$, the higher the confidence, the more likely it is for Y to be present in transactions that contain X.

Confidence also provides an estimate of the conditional probability of Y given X. In the selection of an evacuation route, this method will be applied to see which road in that route frequently traveled together. In this case, support determines how often a rule is applicable to the road taken by the locals while to save themselves. Confidence determines how frequently road Y traveled after road X taken during evacuation process. A rule that has very low support may occur simply by chance or we could say that the attempt to save themselves, they are just guessing which road can be passed safely without having been familiar with the road conditions as best as possible which evacuation route to be taken.

Association rules says that when someone do A, he or she will do B too with a support and confidence value. The bigger support and confidence, then more often the occurrence of A $\rightarrow$ B happen from all. In selecting for evacuation route, this method will use to see association rules of activities and driving social habit. This method will sees is it true that if someone drive on A road will drive on B road too or will drive on other roads too. The rule is different in each village.

Roads conditions in each other is different, there are good roads and there are damaged roads too. Each road will be grouped using hierarchical cluster analysis. Grouping will produce some graded group, very prone to very safe. Variables that will be used is road width, road condition and ease of access road. These variables does not have an indicator to be evaluated, so these variables evaluated using fuzzy logic.

The selection of evacuation road is chosen by people by regarding a their social habit activities and road conditions in each village. Besides those, population in each village is also considered. The selection of evacuation road by local government was directed away from disaster-prone areas of last Merapi's disaster.

2. Related Research

A research to create a map of evacuation routes and the impact area of cold lava floods by utilizing informations from IKONOS images has been done by Ardana and Purwanto. In the research and their paper, the preparation of evacuation route consider to eight parameters. Those parameters are disaster-prone area, slope, length and width of roads, material of roads, the existence of bridges and roads direction [2].

Association rules method can also used in education database. Amiruddin [1] use this method to seek for unique rule of Teacher Certification in data of Nomor Unik Pendidik dan Tenaga Kependidikan (NUPTK), codes of teachers in Indonesia. They found there are 184 rules in the data [1].

Fuzzy logic has been widely applied in real life, one of all is using fuzzy logic to find best supplier for a clothing store. Researcher use Fuzzy Principal Component Analysis and Analytic Hierarchy Process (AHP). Those two methods are a decision-making method that use qualitative and quantitative measurement. Qualitative

measurement define issue and quantitative measurement provide an assessment. This methods use primary data from questionnaires and observation [4].

3. Research Methodology

In the process of selecting evacuation routes, three methods of statistics will be used. First method is association rules, one of many methods of data mining. This method is used to see the rules of people in taking decision for evacuating him or herself and their families. Selecting evacuation routes will be recorded and used as a database to obtain the rules. Those rules can be regarded as a local people habit. Those

rules which will be obtained later, may different for each village, and this rules could be used to decrease accumulation of people on the evacuation route sections risk. Each rule has support (1.2) and confidence (1.3) in percentages. The next method is two methods that are combined, those two methods are hierarchical clustering analysis and fuzzy logic. Fuzzy logic is used to assess the variables which describe the evacuation roads. Those variables are road condition, road width and ease of access road. Those three variables do not have indicators to measure, so the measurement is conducted using simulation of fuzzy logic. Fuzzy set will be divided to seven stratified groups, those groups are:

1. very unsafe,
2. unsafe,
3. little bit unsafe,
4. normal,
5. little bit safe,
6. safe,
7. very safe

Fuzzy set for the three variables is different. Road condition variable is divided into:

1. very bad,
2. bad,
3. little bit bad,
4. normal,
5. little bit good,
6. good,
7. very good.

Road width variable is divided into:

1. very narrow,
2. narrow,
3. little bit narrow,
4. normal,
5. little bit wide,
6. wide,
7. very wide.

Ease of access road variable is divided into:

1. very hard,
2. hard,
3. little bit hard,
4. normal,
5. little bit easy,
6. easy,
7. very easy.

Disaster affected area from the last disaster is also used as a consideration to select evacuation route. The selection evacuation route shows a local people habit. The rule (habit) with the largest support becomes the main recommendation to be the main evacuation route. Smaller support rules used as routes that local people is used to reach the main evacuation route. Those all rules directed away from disaster affected area of last disaster. In this paper, for example, one of some main evacuation routes of Merapi Mountain's evacuation routes, Sleman, Yogyakarta, is used. All the evacuation route are shown in **Figure 3.1**.

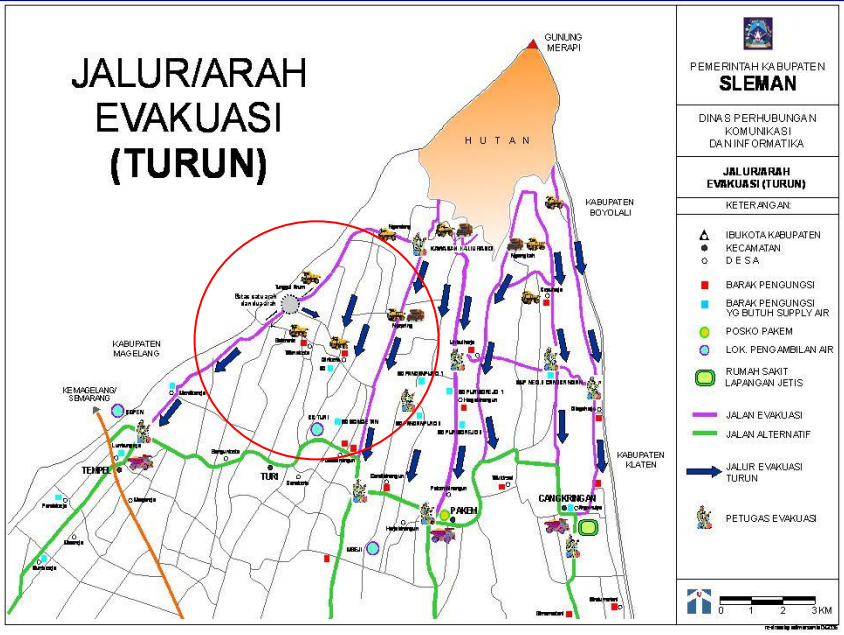

Figure 3.1*Merapi Mountain Evacuation Route*

Source : Sleman District Government (slemankab.go.id)
Evacuation routes which are used as a simulation is circled in red as shown in **Figure 3.2**.

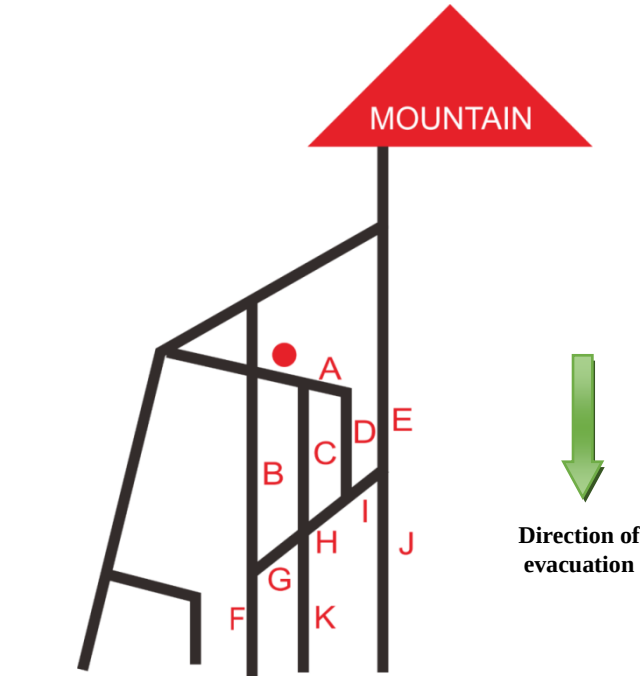

Figure 3.2. *One of Merapi Mountain's evacuation routes*

For example, the road condition of B is shown **Figure 3.3**, road condition of C is shown **Figure 3.4** and road condition of D is shown **Figure 3.5**.

Figure 3.3. *Road B condition*

Figure 3.4 *Road C condition*

Figure 3.5 *Road D condition*

And the affected area of the last Merapi eruption in 2010 is as shown in **Figure 3.6**.

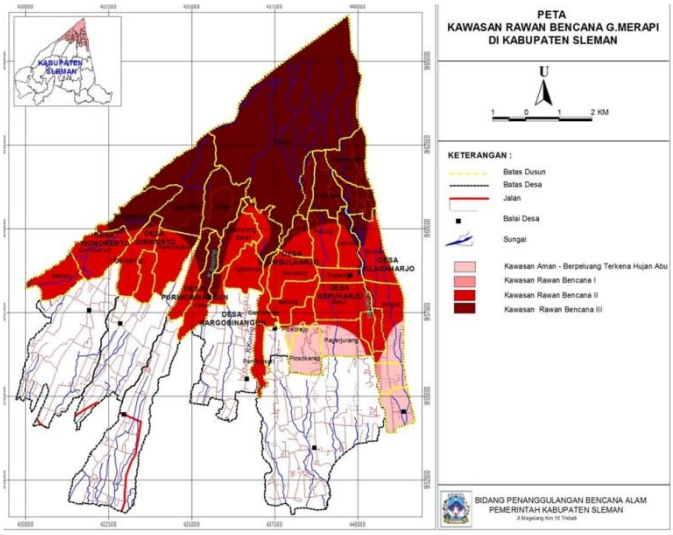

Figure 3.6. *Affected area of Merapi eruption (based on 2010 eruption)*
Source : Sleman District Government (slemankab.go.id)

4. Simulation Study

This study will use a simulation with local people living in the disaster-prone areas. A thousand people were then placed in one area (in **Figure 1.3** colored red dots). Then circumstances made as if it is similar to when Merapi will reach the highest level of warning. After being given a sign to immediately evacuate, then the thousand people hasten to save themselves down the road that they consider the best way to save themselves. After being in a safe place that is determined, then every person who follows the simulation, telling which line he passes to reach a safe point. The result is then recorded as follows.

Table 4.1. Example of the route taken by local residents

Local Residents	Routes
1	C, H, I, J
2	C, K
3	C, G, F
4	A, D, I, J
5	B, G, K
...	
997	B, F
998	A, D, H, K
999	C, H, I, J
1,000	C, K

Using R software and package ‘arules’ to evaluate the support of the data on table 4.1. then we get the following measurements of rules for two routes,

$A \rightarrow I$: 0.17,

$C \rightarrow I$: 0.1,
$C \rightarrow F$: 0.32,
...
$B \rightarrow F$: 0.24,

From these rules, the rule of "$C \rightarrow F$" get the highest value of support. So, rule "$C \rightarrow F$" is the first recommendation to become main evacuation route. However, to reach route F from C, people have to go through route G. Thus the existing rules instead of $C \rightarrow F$ bute became $C \rightarrow G \rightarrow F$. Therefore, this rules recommends that the main evacuation route is $C \rightarrow G \rightarrow F$.

The second biggest support is $B \rightarrow F$ rule route, so that rule become second recommendation to become main evacuation route or ordinary evacuation route to reach main evacuation route for a while. The third is $A \rightarrow I$ rule route and become third recommendation, and so on until the smallest support. Road condition of those all rule route are also considered.

From direct observation of the existing roads, it appears that the road B (figure 3.3) has poor road conditions and can harm people when they pass through in large numbers and panic. The condition of road C (figure 3.4) rather bad, while the condition of the road D (figure 3.5) look good, but after the barrel located in the middle of the road, the left side of the road was severely damaged. Those three roads have same width. By considering the real roads conditions, then the best choice is road C. Direct observation was also conducted to assess the other roads.

From observation, seems that route B (**Figure 3.3**) is damaged and endanger local people if they pass through that route. Route C (**Figure 3.4**) is bit damaged and route D (**Figure 3.5**) is in very good condition but after the drum, there is landslide on the left side of the road. Those three route is also have same width. In simulation, roads condition for each route is below:

Table 4.2. Roads condition for each route

Route	Condition	Width	Ease of Access
A	Bad	Normal	Very easy
B	Bad	Normal	Easy
C	Bit bad	Normal	Easy
D	Very bad	Normal	Easy
E	Good	Wide	Hard
F	Bit bad	Bit wide	Bit hard
G	Normal	Bit narrow	Bit hard
H	Bad	Bit narrow	Bit hard
I	Normal	Bit narrow	Easy
J	Very good	Very wide	Hard
K	Good	Wide	Hard

Using hierarchical clustering (complete linkage) with R software, got dendrogram below:

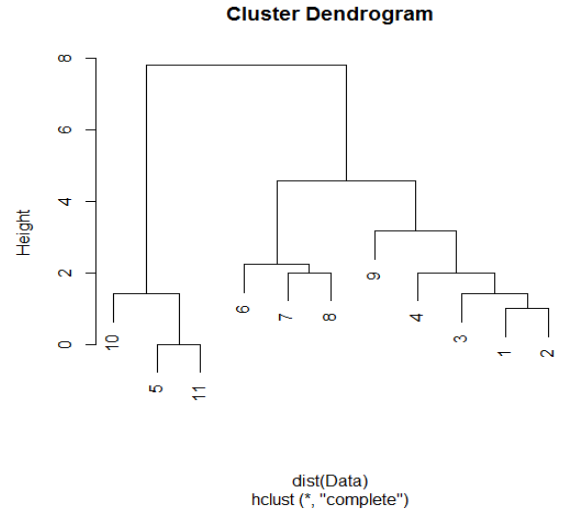

Figure 4.1. *Dendrogram of road conditions*

Note that,

1 : Route A
2 : Route B
3 : Route C
4 : Route D
5 : Route E
6 : Route F
7 : Route G
8 : Route H
9 : Route I
10 : Route J
11 : Route K

From the dendrogram, use height of almost 2, seem that route A, B and C is the best road or can said as group Very Safe at that village. Route D grouped into group Safe, route I grouped ino group Bit Safe, and so on until group of route J, E and K.

From the result of association rules, fuzzy hierarchical clustering and direct observation of road conditions, rules C $\rightarrow$ G $\rightarrow$ F become the first recommendation to be main evacuation route.

The second evacuation route and so on can be determined in the same manner. These results can then be provided to the competent authorities in the evacuation problem. Thud dividing routes could consider road capacity and the number of actual residents in order to avoid excess capacity at one point causing congestion and excessive panic.

4. Result and Discussion

Results and conclusions are as follows:

1. selection of evacuation route with this method can decrease accumulation of people on the steps of the evacuation route risk,

2. if this method is used in real life, the hardest part is to record activity and driving people data. Same person must recorded from first place, then their travel road, until their destination. And the next part why this part is the hardest part is because data mining analysis need big data, very big data to obtain relevant result, and
3. for the development of this method, small area estimation method can use to estimate the disaster-prone area and many simulation possibility of evacuation process, so probability of people safe on every part of evacuation route can be calculated.

References

[1] Amiruddin, *Penerapan Association Rule Mining pada Data Nomor Unik Pendidik dan Tenaga Kependidikan untuk Penetapan Pola Sertifikasi Guru* (*The Implementation of Association Rule Mining on NUPTK Data To Determine Teacher's Certification*). Tesis (TE 2099), Institut Teknologi Surabaya, 2010.

[2] Ardana, D.M.S., Purwanto, T.H., 2012, *Penentuan Jalur Evakuasi dan Dampak Banjir Lahar Dingin Gunung Merapi (Select An Evacuation Route and The Impact of Cold Lava Flood from Merapi Mountain)*, Page 149.

[3] BeritaJatim.com. Warga Histeris, Jalur Evakuasi Macet Total http://m.beritajatim.com/peristiwa/198365/warga_histeris,_jalur_evakuasi_mmace_total.html#.U1jF5_mSxmw 24 April 2014

[4] Muhajir, Muhammad, 2011, *Pendekatan Metode Fuzzy Principal Component Analysis dan Analytic Hierarchy Process dalam Pemilihan Supplier Terbaik Produk Bahan Baku Baju (Fuzzy Principal Component Analysis and Analytic Hierarchy Process Methods Approach to Select Best Raw Material Dress Products Supplier), Page 17.*

[5] The Secret of Mindpower and NLP, Anxiety Panic Attacks http://www.the-secret-of-mindpower-and-nlp.com/anxiety-panic-attacks.html 22 April 2014

[6] Thomas E. Drabek. 1990. *Emergency Management: Strategies for Maintaining Organizational Integrity*. New York: Springer-Verlag.

[7] Gheorghe Savoiu, 2003, *The holistic concepts of disaster management and social cohesion – statistics and method*, Scientific Bulletin – Economic Sciences Vol. No. 10/Issue 1)