Comparative study of landslides susceptibility mapping methods: Multi-Criteria Decision Making (MCDM) and Artificial Neural Network (ANN)

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Abstract. As different approach produces different results, it is crucial to determine the methods that are accurate in order to perform analysis towards the event. This research aim is to compare the Rank Reciprocal (MCDM) and Artificial Neural Network (ANN) analysis techniques in determining susceptible zones of landslide hazard. The study is based on data obtained from various sources such as local authority; Dewan Bandaraya Kuala Lumpur (DBKL), Jabatan Kerja Raya (JKR) and other agencies. The data were analysed and processed using Arc GIS. The results were compared by quantifying the risk ranking and area differential. It was also compared with the zonation map classified by DBKL. The results suggested that ANN method gives better accuracy compared to MCDM with 18.18% higher accuracy assessment of the MCDM approach. This indicated that ANN provides more reliable results and it is probably due to its ability to learn from the environment thus portraying realistic and accurate result.

1. Introduction

The landslide is one of the natural disasters that are significantly related to our country, multiple cases are reported throughout the entire country. The landslide is defined as the movement of a mass of rock, debris, or earth down a slope [1]. In a simple word, it is basically a type of mass wasting that relates to downslope movement of mass such as soil or rock with the influence of gravity.

It is usually triggered by the movement of the slope that forces the down-slope movement with the mass and surface structure that exist on the slope [2]. Other than that, climate changes also play a role and impact in triggering landslides. Other factors related in triggering the occurrence of landslides in an earthquake, heavy rainfall and other geological causes [3]. Each time landslide occurs, it changes the structure and surface cover of the area. Besides that, it causes a massive loss in terms of property damage, effect on resources and biodiversity and also it may lead to injury and death [4].

Back in 1993, a landslide event occurred at Highland Towers affecting hundreds of people killing more than 50 people. Based on the studies done by the agencies involved such as Ampang Jaya Municipal council (MPAJ) and Jabatan Kerja Raya (JKR), it is found that one of the factors that contribute to the landslide events is the presence of rainfall besides issues with the inadequate constructed drainage. During the month of November to January, rainfall season is the most intense

period that leads towards landslides, mudslides and floods. During this period, flood and landslide occurred at a rapid rate and risk area such as Kuala Lumpur is vulnerable to flash flood and landslide event. The existence of rainfall triggered the movement of geology at the location, making it loosen and eventually fall [5].

Landslide is not something new and mitigation action needs to be taken in order to prevent it from occurring again. Mapping the risk area is crucial in determining susceptible zones to help in decision making for urban planning and management. One of the popular methods in mapping susceptible zones is by using Multi-Criteria Decision Making (MCDM) and also Artificial Neural Network (ANN). The approach taken by the government is the establishment of the National Slope Master Plan (NSMP) that provides detailed elements in a comprehensive and effective way to describe the national policy. It includes policy, strategy and also action plan in reducing the risk of landslide events. It focuses on nationwide scopes that started back in 2009 till 2023 [6].

1.1. Kuala Lumpur geographical characteristics

Kuala Lumpur is the city centre of Malaysia which located in the centre state of Selangor. It is also known as Klang Valley and surrounded by various types of topographic features such as Titiwangsa Mountains in the east side, several ranges on the north and south while Malacca Straits on its west. The city has a tropical rainforest climate which is warm and sunny alongside abundant rainfall. The rainfall season usually occurs during northeast monsoon period of October to March. Due to monsoon season, Kuala Lumpur is frequently struck by flood and landslide occurrence especially during intense rainfall.

2. Methodology

The conceptual framework of the study is summarised in Figure 1. It consists of six phases beginning with the process of determining of issues, literature review, and selection of criteria, data collection, data processing and analysis. Each of the phases describes the process in achieving the objectives of the study.

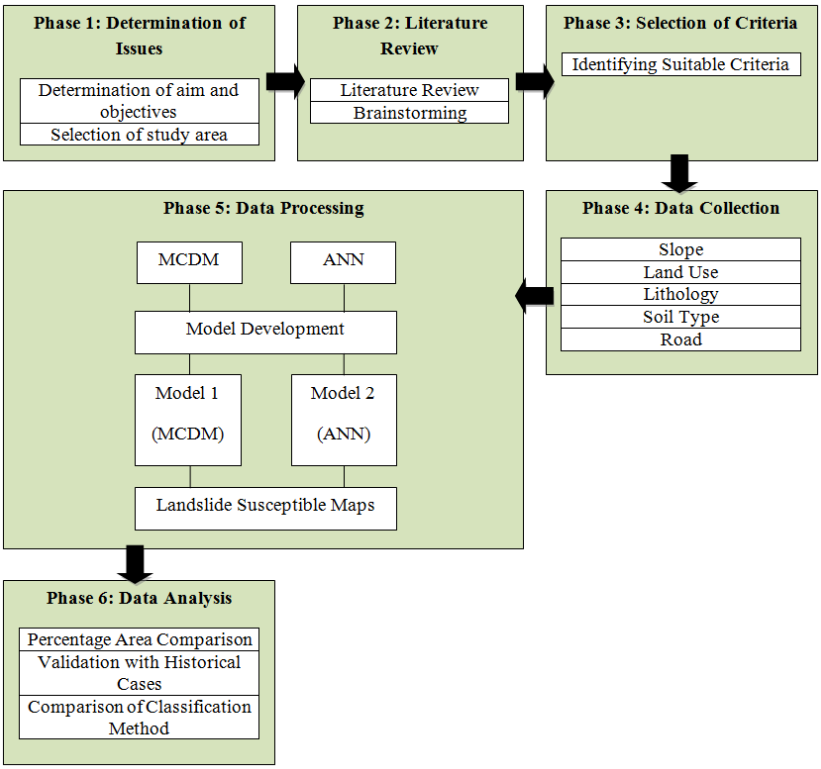


Figure 1. Conceptual framework

2.1. Data Collection

Based on discussion with various experts and government agencies, 5 selected criteria were used, slope, land use, lithology, soil type and proximity to road. The criteria involve in this study is collected from Kuala Lumpur City Council (DBKL). The slope is generated from the DEM surface that is based on LiDAR data while other layers acquired are in vector form. Besides that, previous location and historical data is captured based on landslide occurrence and previous study. Land use data are classified into six classes such as agriculture, grassland, forestry, rubber, unused land and urban area. While for lithology layer, it consists of five types of lithology that exist in the study area (i.e. acid intrusive, limestone, phylite, slate, shale and sandstone, schist, schist, phylite, slate and limestone). The soil type in the study area consists of several types of soil such as mined land, munchong, rengam, serdang, steepland, telemong and urban land. The proximity to the road is categorized into five classes, each with an interval of 40 meters (0-40m, 40-80m, 80-120m, 120-160m, 160-200m).

2.2. Data Processing

2.2.1. Multi Criteria Decision Making (MCDM) Technique. In MCDM, there are various techniques that can be used in assigning weightage to the criteria. One of the techniques is by ranking method, Rank Reciprocal (RR). In RR, it uses the technique of deriving the weighted value from normalize reciprocals of a criterion rank. It uses a formula to calculate each of the criteria weight. The formula of Rank Reciprocal is shown below, where wi is the weight value for each criteria and rj is the rank of each criteria [7].

$$wi = [1/rj\ ] / \Sigma\ (1/ rk) \quad (1)$$

Based on interviews and discussions with expert, the score for each of the criteria is obtained. From the score, weight is calculated based on formula to perform a model. The model for landslide susceptible zones is shown in Equation 2.

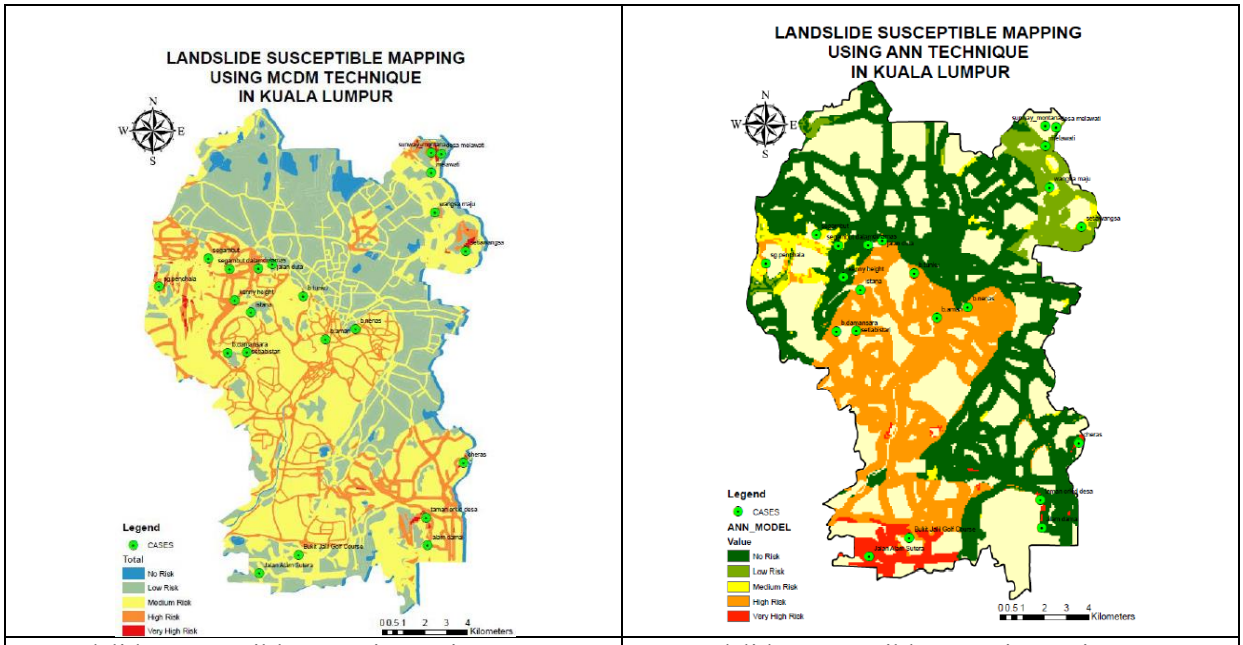
$$LHZ = (0.438 * s\_slp) + (0.109 * s\_rd) + (0.146 * s\_lith) + (0.219 * s\_lu) + (0.088 * s\_st) \quad (2)$$

Where *s_slp* is the standardized score for slope sub critera, *s_rd* is the standardized score for proximity to road sub criteria, *s_lith* is the standardized score for lithology sub criteria, *s_lu* is the standardized score for land use sub criteria and *s_st* is the standardized score for soil type sub criteria.

2.2.2. Artificial Neural Networks (ANN). ANN uses experience and training sites to learn from and produce results. The key element of the process is the structure of information processing system [8]. The methods are configured basically for a specific purpose and application such as pattern recognition or data classification. It learns from the biological systems and performs adjustments to the connection that exist between neurons. The model adopts the changes in the structure based on the information then flows through the network during its learning phase. ANN requires a learning algorithm to perform the model network [9]. Training sites are essential, the training site method consists of two, supervised and unsupervised. For supervised training method, the input and output of the study are provided to the network. It will then process both data and compare the output against the desired outputs. From the comparison process, an error is determined and propagated back through the system. After that, the system will then readjust the weight assigned to the inputs until the weight is reliable.

3. Results and Discussions.

The landslide susceptible maps from both methods are shown in Figure 2. The results are overlaid with historical cases and it is classed into five classes (i.e. no risk, low risk, medium risk, high risk and very high risk). From the result, the total area was compared.



Landslide Susceptible Mapping Using MCDM Method	Landslide Susceptible Mapping Using ANN Method

Figure 2. Landslide susceptible mapping using MCDM and ANN methods.

3.1. Comparison of Risk Area between MCDM and ANN

Table 1 explains the area covered for all risk classes using both methods. There are differences in risk area coverage between MCDM and ANN methods. For example, in medium risk, MCDM covers a total of 115.57 square kilometres while ANN method covers only 5.97 square kilometres.

Table 1. Comparison of Area for MCDM and ANN Methods

Risk Ranking	MCDM [Area (sq km)]	ANN [Area (sq km)]
No Risk	10.438702	87.144128
Low Risk	80.391987	11.542029
Medium Risk	115.574903	5.974561
High Risk	36.929774	49.259483
Very High Risk	1.213424	6.205911

3.2. Accuracy Assessment between MCDM and ANN with Historical Cases

Table 2 below shows the comparison of results between both methods in terms of historical cases. The result from both methods is compared to see the differences of zoning for the previous cases location. The classification method used for both result is Natural Break classification [10]. It shows that MCDM technique has the accuracy of 50% comparing to historical cases while ANN technique scores 68.18% of accuracy comparing to historical cases.

Table 2. Comparison of Zoning Classification for MCDM and ANN Method

Name of Cases	Zoning	MCDM Zoning	ANN Zoning
Bukit Tunku	High	Medium	High
Cheras	Very High	Very High	Very High
Bukit Damansara	High	Medium	High
Bukit Nenas	High	Medium	High
Segambut	High	High	High

Name of Cases	Zoning	MCDM Zoning	ANN Zoning
Segambut Dalam	Low	High	Low
Setiabistari	High	Medium	High
Setiawangsa	Medium	Medium	Medium
Taman Melawati	Medium	Medium	Low
Wangsa Maju	High	High	Medium
Kenny Height	Low	High	Low
Jalan Duta	High	Low	High
Taman Orkid Desa	Very High	Very High	Very High
Istana Negara	Medium	Medium	-
Bukit Aman	High	High	High
Sunway Montana	Low	Very High	-
Dutamas	High	High	High
Alam Damai	Medium	Medium	No Risk
Sungai Penchala	Very High	Very High	High
Desa Melawati	Low	High	-
Jalan Alam Sutera	Very High	Low	Very High
Bukit Jalil Golf Course	High	Medium	High
	Percentage	50%	68.18 %

Table 3 below shows the comparison of results by classification methods with historical cases. The result from both methods is compared to see the differences of zoning for the previous cases location. The classification method used for both result is Quantile classification technique. From the result, it shows that MCDM technique has the accuracy of 54.54% comparing to historical cases while ANN technique scores 68.18% of accuracy comparing to historical cases.

Table 3. Comparison of Zoning Classification for MCDM and ANN Method using Quantile Classification Technique

Name of Cases	Zoning	MCDM Zoning	ANN Zoning
Bukit Tunku	High	High	High
Cheras	Very High	Very High	Very High
Bukit Damansara	High	Medium	High
Bukit Nenas	High	Medium	High
Segambut	High	High	High
Segambut Dalam	Low	High	Low
Setiabistari	High	Medium	Very High
Setiawangsa	Medium	Medium	Medium
Taman Melawati	Medium	Medium	Medium
Wangsa Maju	High	High	Medium
Kenny Height	Low	High	Low
Jalan Duta	High	No Risk	High
Taman Orkid Desa	Very High	Very High	Very High
Istana Negara	Medium	Medium	-
Bukit Aman	High	High	High
Sunway Montana	Low	Very High	-
Dutamas	High	High	Low
Alam Damai	Medium	Medium	Low
Sungai Penchala	Very High	Very High	Very High
Desa Melawati	Low	High	-
Jalan Alam Sutera	Very High	Low	Very High
Bukit Jalil Golf Course	High	Medium	High

Name of Cases	Zoning	MCDM Zoning	ANN Zoning
	Percentage	54.54 %	68.18 %

4. Conclusion and Recommendations

Both MCDM and ANN can produce reliable results in mapping susceptible zones for landslide event. Each method has its own uniqueness in processing data to achieve the aim and objective of the study. The results indicated that ANN method can provide more reliable as it portrays much realistic information through its result based on its ability to learn from the environment as compared to MCDM where the result is generalized at certain area. Through the process of accuracy assessment, ANN produces better accuracy with 68.18% as compared to the MCDM method with 50% accuracy. It was suggested that accurate data such as land use data will produce more accurate results. Other than that, comparing results from both techniques with other methods such as Fuzzy Membership in order to validate the results obtained. Perhaps, by having more historical cases, it will also help in determining the training sites for ANN method while it can be used to validate the model and the result accurately.

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