CLIMBER RISK PROFILE MAPPING AND CLUSTER ANALYSIS OF CLIMBING ROUTES: A CASE STUDY OF MOUNT SINDORO, TEMANGGUNG, CENTRAL JAVA

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Abstract. Hiking is a popular form of tourism. However, the number of injuries and casualties resulting from inadequate preparation is a significant concern. Previous research has focused on mapping visualisation, calorie measurement, and climbing logistics on hiking trails, and on developing hiking simulations based on climate and climbing capacity. Furthermore, risk mapping on hiking trails and risk assessment models are needed. This still requires further study, given that the difficulty level of hiking in mountainous areas in Indonesia lacks clear standards. Therefore, it is necessary to develop trail risk mapping that links climber/porter factors to environmental conditions to provide recommended risk assessments for specific profile conditions. This can be used to evaluate existing models and assess the risk of hiking trails in general, as well as specifically for the Mount Sindoro Trail in Temanggung, Central Java. Two approaches were used. The results showed that the SVM algorithm was able to classify the risk profiles of climbers with a Support Vector Machine (SVM) accuracy of 90.35%. Meanwhile, clustering using the K-Prototype method supports optimisation of trail management, facility efficiency, and decision-making for risk mitigation. This research requires further validation to provide data-based recommendations to relevant agencies to support improvements to the hiking trail information system in Indonesia.

Keywords: Mount Sindoro, mapping, hazard risks, climbing, model

1. Introduction

Indonesia has abundant natural resources, including 129 active and approximately 500 inactive volcanoes [9] [15]. 30% of global tourism revenue comes from adventure tourism, including outdoor activities such as hiking, trekking, climbing, surfing, rafting, and scuba diving [3], for recreation, expeditions, or research, and it demands physical strength, motivation, and mental resilience [12] [10]. Although mountain climbing activities offer various health benefits, they also entail subjective and negative hazards. The number of injuries and casualties resulting from inadequate preparation is a significant concern.

The death rate from 2013 to 2020 continued to increase; 88 cases of climbing-related deaths occurred on the mountain, caused by several factors such as hypothermia, getting lost, falling, physical drop, fire, being hit by a rock, heart attack, and others [6] [11] [7]. Risk is the uncertainty arising from changes or deviations from expectations [1]. The absence of a national standard for the difficulty level of hiking trails poses a challenge. Indonesian Mountain Guides Association (APGI) is developing a trail grading system to enhance the

safety and comfort of hikers [4]. Hiking can be analysed through a systems approach, encompassing ergonomics, quality, logistics, and risk management, to improve data-driven safety [2] [13] [14]. The underlying rationale for this research is the lack of standards for climbers based on input data that can be used to model these risks.

It is necessary to determine the parameters to be considered when assessing risk recommendations for climbers and porters, based on hiker/climber profiles and specific mountain characteristics. Risk profiling refers to the process of identifying the risks that an individual or group may face and determining which risks are acceptable [9]. The profile is clustered by risk category. Research by Pernama and Purnomo [15] shows that SVM is effective in risk classification, with an accuracy of 92%, a precision of 0.8750, and a recall of 0.9844, outperforming methods such as Artificial Neural Networks (ANN) and Naïve Bayes on the dataset used. Meanwhile, the K-Prototypes method has the highest internal cluster validation value among the methods, at 0.3796 [15].

The implementation of Occupational Health and Safety (OHS) in the tourism industry is governed by government regulations in Law No. 10/2009 concerning Tourism, specifically Articles 20 and 21, which cover tourists' rights to legal protection, security, safety, and insurance for high-risk activities. This study aims to cluster mountain hiking trails in Indonesia using clustering methods, focusing on trail characteristics. The clustering results can provide clear information, helping hikers select trails according to their abilities and goals.

2. Methods

The data used is both secondary and primary data. Secondary data were obtained from online sources, while primary data were obtained from interviews with climbers with experience on the respective trails. There were 2 sets of questionnaires (Certificate of Free Ethical Review number: 01.059/KEP-SOSHUM/IX/2025), with 114 respondents in the data profile. The data was processed descriptively and using a web-based Support Vector Machine (SVM) and K-Prototype Method. The modelling will focus on data from the ascent of Mount Sindoro to the summit, particularly the Kledung route as a sample.

3. Results And Discussion

3.1. Description

The collected data from existing hiking trail information for mountains with an altitude. After data collection, a recapitulation of the physical characteristics of respondents was obtained in Figure 1 as follows.

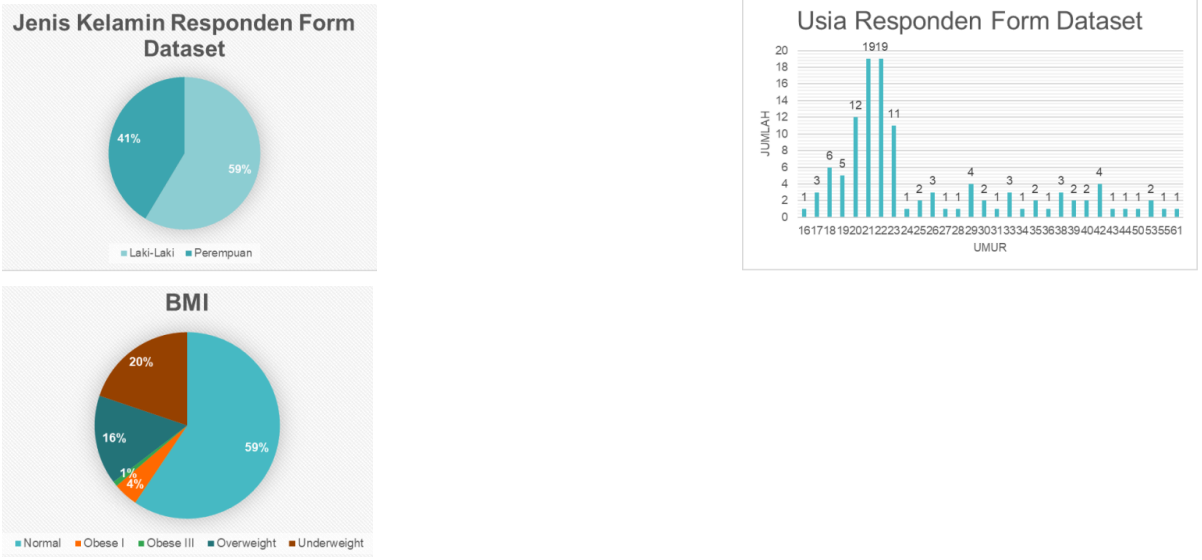
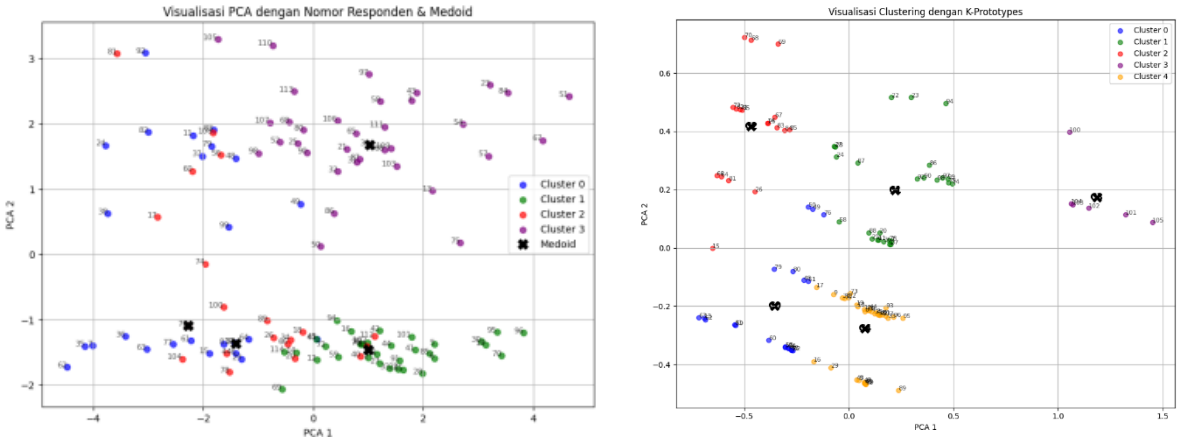


Figure 1. Description of the respondents

The composition of male respondents was 59%, and female respondents were 41%. Most respondents were aged 18–23 years, and the majority had climbed in the past year. Additionally, 59% of respondents fell within the normal Body Mass Index (BMI) range (18.5–24.9).

3.2. Clasterization

To identify individual climber factors that influence climbing risk, a validity test using Pearson correlation was conducted, with reference to the elimination order based on R and P-values. 14 of the 19 items studied were declared valid. The clustering resulted in the following number of class members: cluster 1, 26; cluster 2, 33; cluster 3, 20; and cluster 4, 35 (Figure 2a). Based on support vector machine (SVM) results, there are four hazard risk categories, ranging from very dangerous to very safe. Parameter tuning with C1 and gamma set to 0.01 yielded an accuracy of 90.35%.



(a) (b)

Figure 2. Dataset Clustering Results Using (a) Fuzzy K-Medoids and (b) K-Prototype

The K-Prototype method (Figure 2b) grouped 105 mountain-climbing routes in Indonesia into 5 clusters based on numerical variables (height, elevation, and route length) and

categorical variables (land cover, steepness, availability of water sources, and availability of supporting facilities). Mount Sindoro's altitude is 3153 mdpl, with 6 hiking tracks, which are Kledung, Alang-alang Sewu, Ndoro Arum, Sigedang, Bansari, and Bedakah. The risk profile for Mount Sindoro, based on the clusterisation model, is presented in Table 1.

Table 1. Risk Profiling/Clustering of Mount Sindoro

No	Hiking Trails	Altitude (mdpl)	Elevation (m)	Land Cover	Trail Length (km)	Steepness	Water Source Availability	Supporting Facilities Availability
				Basic (Cluster 1)				
1	Sindoro Via Kledung	3153	1757	*Class* 2	5,88	*Class* 3	No	*Class* 1
2	Sindoro Via Alang-alang Sewu	3153	1811	*Class* 2	6,33	*Class* 3	Yes	*Class* 2
3	Sindoro Via Ndoro Arum	3153	1640	*Class* 2	5,8	*Class* 3	Yes	*Class*3
4	Sindoro Via Sigedang	3153	1347	*Class* 2	4,69	*Class* 3	Yes	*Class* 3
5	Sindoro Via Bansari	3153	2084	*Class* 2	7,93	*Class* 3	Yes	*Class* 2
6	Sindoro Via Bedakah	3153	1859	*Class* 2	6,31	*Class* 3	No	*Class* 1

The Category “Basic 1" cluster comprises climbing routes with an average height of 2,988.65 meters above sea level, an average elevation of 1,393.3 meters, and an average length of 7.466 kilometers. The dominance of land cover is in class 2, namely grasslands, grasslands, savannas, the dominance of steepness in class 3, namely scrambling with open places requiring handrails and the use of ropes and the risk of fatal falls with a slope of 16-35º, the dominance of the availability of available water sources, and the dominance of the availability of supporting facilities 5 out of 5 supporting facilities. This cluster has the second-lowest average elevation and features low land cover and steep slopes, particularly in class 2, with available water sources and adequate supporting facilities.

This climber risk-profiling classification system is constrained by the number of datasets used as the basis for classification. The researcher's primary suggestion for future research is to increase the number of datasets to include more data and better variation.

4. Conclusion

Based on support vector machine (SVM) results, there are four hazard risk categories, ranging from very hazardous to very safe. The results of parameter tuning with C1 and gamma = 0.01 are 90.35% accurate. K-means is a clustering algorithm that partitions data into k clusters. Mt. Sindoro (via Kledung, Alang-alang Sewu, Ndoro Arum, Sigedang, Bansari, and Bedakah) is categorised “Basic 1": the route is open and easy enough to traverse with adequate supporting facilities and not too extreme elevation. This climber risk-profiling classification system is limited by the number of datasets used as the basis for classification. This research requires further validation to provide data-based recommendations to relevant agencies to support improvements to the hiking trail information system in Indonesia.

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