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Location analysis for petrol filling station based on stakeholders' preference and seismic microzonation

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Abstract

The determination of petrol filling station location in Surabaya has not considered the stakeholders' preference on environmental safety perspective and also the sub surface condition yet. As a vital facility, this condition may lead to disastrous condition. Thus, the objective of this paper is to recommend petrol filling station location which is safe for environment and living community in surrounding. As the extend of previous work which is focus on stakeholders' preference, this current work emphasized on subsurface condition which may influence the stability of petrol filling station infrastructure. However, the result of previous study still will be presented to keep the good coherence of the discussion. Three stages have been set up to reach the objective of this study. Firstly, assess the stakeholder's preference for petrol filling location criteria using AHP method. Secondly, assess and mapping the seismic microzonation using fuzzy clustering method. Thirdly, suitability analysis based on stakeholder's preference and seismic microzonation to find recommended location using GIS method. As the result of the study shows that based on stakeholder's preference, the proper selection of land use criteria appears as the most important criteria for determining petrol filling station location and yielded 31,2% influence. Based on seismic microzonation, the North part of Surabaya mainland from East to West which is near to Madura Straight is high susceptible for local seismic. As a conclusion based on the overlay mapping of these two findings, the Central part of Surabaya heading to West is the most suitable location for petrol filling station. The result of this study could be used as an evaluation for existing petrol filling station location or either for future preference. In another hand, it could be a very useful recommendation for zoning regulation to control the development of petrol filling station which doesn't concern environmental safety.

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Keywords: Petrol filling station; AHP; GIS; and seismic microzonation.

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1. Introduction

The existence Petrol Filling Station (PFS) are increasingly needed as the rapid growth of vehicles in urban areas. In Surabaya, PFS has reached over 90 stations scattered in some parts of the city [1]. This amount is proportional with the number of vehicles that reach 2.477.368 units. In the future, as the increasing number of vehicles in Surabaya the needs of PFS will also rise up. This condition puts PFS as a new business opportunity which now days influence the increasing of establishment permission request.

PFS as a sensitive facility which contains flammable substance may lead to disastrous consequence to its site and surroundings. Ground water and surface water contamination; open fire and explosion; VOC (Volatile Organic Compound) emission; and traffic obstruction are potential hazards which may occur on site and give impact to surroundings due to accident or carelessness [2]. These potential hazards will be more dangerous if associated with seismic. The quake will cause vibrations which eventually may trigger severe danger as mentioned earlier.

Pertinent to seismic issue, some local area of Surabaya has high tremor intensity due to earth quake [13]. This high intensity tremor condition will be a great potential hazard since PFS' equipment such as USTs (Underground Storage Tanks) and pipe line are installed beneath surface. UST's or pipe line leakage could lead to soil and water contamination and not impossible at certain level tremor could trigger an open fire and explosion. Thus, it is very important to map the suitability analysis of PFS not only based on stakeholder's preference but also take into account the seismic microzonation, both used as a baseline to determine PFS location development guide line.

2. Methodology

2.1. Spatial Multicriteria Decision Analysis

Spatial multi criteria analysis requires information on criterion values as well as the geographical locations of alternative sites. Additionally, preferences of a set of evaluation criteria chosen by the decision makers will also aid in suitable analysis. This means, the analysis results not only depends on the geographical distribution of attributes, but also on the value judgments involved in the decision making process. Two available techniques that provide a significant contribution in spatial multicriteria decision analysis are: (1) the GIS component and (2) the Multi Criteria Decision Making (MCDM) analysis component [11, 9]. In solving spatial decision problems, GIS and MCDM techniques support the decision makers to achieve greater effectiveness and efficiency of decision making.

The purpose of criterion weighting is to express the importance of each criterion relative to other criteria. Weighting of criteria can be done in several ways: ranking method, rating method, pair-wise comparison method, trade-off analysis method, and comparing method. However, empirical applications suggest that the pair-wise comparison method is one of the most effective techniques for spatial decision making including with GIS-based approaches [5].

The pair-wise comparison method was developed by Saaty in the context of the Analytic Hierarchy Process (AHP) [12]. The analytical hierarchy process (AHP) method is based on three principles: decomposition, comparative judgment, and synthetic of priorities [6]. This method involves pair-wise comparisons to create a ratio matrix. It takes as an input the pair-wise comparisons and produces the relative weight as output. Specifically, the weights are determined by normalizing the eigenvector associated with the maximum eigen value of the (reciprocal) ratio matrix.