

**CONFIGURING SUITABLE LANDFILL
WITH GIS-NETWORK ANALYST
CASE STUDY MUNICIPAL OF BATAM- INDONESIA**

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CASE STUDY MUNICIPAL OF BATAM-INDONESIA**

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**A thesis submitted in fulfillment of the requirement for
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ABSTRAK

Kajian ini menggunakan Analisis Jaringan dalam Sistem Maklumat Geografi (GIS) bagi membangunkan model penjanaan senario dan mengenalpasti pilihan tapak pembuangan sampah alternatif bagi Kota Batam. Ia berpandukan kepada pemilihan tapak berdasarkan aspek ekonomi dan seterusnya mengenalpasti laluan terbaik ke tapak yang terdekat. Hasil kajian ini diharapkan dapat digunakan dalam membantu Kerajaan Kota Batam dalam mempertimbangkan projek tapak pembuangan sampah di bandar tersebut. Proses awal kajian melibatkan pemilihan tapak pembuangan sampah melalui proses tindih lapis (*union*) lapisan data guna tanah (tidak termasuk Kawasan Sensitif Alam Sekitar), buffer jalan, daerah permukiman lapangan terbang serta kecerunan dengan yang kemiringan kurang daripada 20%. Tiga pilihan tapak terbaik diperolehi melalui proses analisis tersebut. Kemudian, pembinaan topologi bagi lapisan data jalan dibuat dan perletakan titik peralihan/transit bagi pengumpulan sampah (sebanyak 265 titik) ditentukan. Set data jaringan (*network dataset*) bagi lapisan data jalan yang mengandungi parameter dan spesifikasi jalan dibentuk untuk digunakan dalam menjalankan analisis jaringan dalam ArcGIS 9.2. Analisis kawasan perkhidmatan (*service area*) dalam ArcInfo Network Analyst dilakukan dengan mengambilkira tahap tadahan tampungan perkhidmatan kawasan bagi ketiga-tiga tapak dalam masa 5, 15 dan 30 minit. Hasil yang diperolehi mendapati dan diputuskan ialah tapak alternatif 3 kerana walaupun tidak memiliki cakupan tadahan tampungan, tetapi memiliki *transit point* yang terbanyak dan dapat menampung lebih banyak sampah. Bagi memperkuat hasil kajian ini ditentukan titik *origin destination* dan 10 titik peralihan terjauh dalam setiap daerah ditentukan. Seterusnya, laluan terbaik akan dijana melalui ArcInfo Network Analyst dalam ArcGIS. Hasil yang diperolehi mendapati dan diputuskan ialah tapak alternatif 3 kerana memiliki daerah cakupan tadahan tampungan yang terbanyak dan dapat menampung lebih banyak sampah walaupun tidak memiliki jarak laluan terpendek dengan waktu yang paling minima. Didapati hasil kajian menunjukkan tapak alternatif 3 sememangnya merupakan lokasi terbaik bagi tapak pengumpulan sampah di Kota Batam.

ABSTRACT

This study meant to apply Network Analysis in GIS to develop scenario generation model and assess alternative landfill sites in Batam City based on the economical aspects. And the best route to achieve the closest landfill. Results of this study might help the government of Batam City to consider about the landfill projects in the city. Landfill alternative selection started by unionizing the layer landuse (excluding Environment Sensitive Area), road buffer, residential, airport, and slope lower than 20%. Road topology and transit point were done afterwards (for 265 points), in order to avoid layer overlapping in the form of shapefile. Road layer (shapefile) converted to network dataset to add parameter and road specification. The analysis were done to show the size of the covered area in every 5, 15, and 30 assumed minutes. The result was alternative number three, because even it did not has the wide area covered, it has more transit point and more waste generate. In order to support this result, then OD (Original Destinations) are added and 10 furthest transit point were defined. ArcInfo Network Analysis assessed the landfill alternatives. The result was alternative number three, because it has more transit point and more waste generate even it did not the closest route and fastest time-span. Site 3 showed the more area covered then other alternative sites.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Solid waste problem is quite a continuing important urban issue. Along with the rapid urban growth, the amount of solid waste is growing exponentially, and needs more attention from local governments. The price of the land increases along with the rapid urban growth as well, and makes it more difficult for the government to find an appropriate landfill location. In some large and medium-sized cities in Indonesia, governmental actions in term of landfill are limited by such factors. In the year of 2000, only 40% of the solid waste has taken into appropriate process. Unprocessed or untreated solid waste triggered the air, water, and land pollutions, as well as increasing the probability of flood in urban area. Landfill problems should be seriously, technically, rationally, and professionally solved. It takes an integrated management, based on the situation, condition, and policy of each region in the country.

The increase of the amount of the solid waste, combined with the scarcity of the landfill, created serious problems for urban areas in order to maintain the balance of the environment. Landfill, which should be an environment-friendly end of the chain of the waste management; nevertheless, limited funding and human resources, plus the existing pattern of 'collect-carry-dump', put an enormous burden to the existing landfill. There is not enough landfill, and the capacities of the existing landfills are reaching their limits.

Regional autonomy (*Otonomi Daerah*) administratively separated one town to another; hence, the regional landfill management is difficult to be discussed among regions. Some major factors of the problem are as follows: (1) the scarcity of land in urban area, especially in metropolists; (2) regions and districts stated their objections on having landfills in their areas due to NIMBY (Not in My Backyard) syndrome; (3) there is no specific body or agency that responsible for the solid waste management. On top of those factors, some illiterated citizens did not realize about the importance of not littering. The national government ratified some international agreements such as Agenda 21, MDG 2015, Kyoto Protocol, which needs to be realized, while the government published the national regulation of solid waste management (UU 18/2008) as a legal platform in managing solid waste and landfill.

Housing estates, commercial estates, industrial estates, and institutional estates were created by the urbanization process. These activities attracted numbers of citizens; hence the overpopulation. The overpopulation means more solid wastes. Based on the statistical counting of Bappenas, in 1995, piled solid wastes of Indonesia was predicted to be 22.5 millions of tons, and multiplied in 2020 to 53.7 millions of tons. Meanwhile, in the major cities of Indonesia daily solid waste per capita is estimated around 600 – 830 grams. To illustrate the amount of solid waste in the country, several major cities conditions might be taken as references. Jakarta produces 6.2 thousands of tons of solid wastes, Bandung produces 2.1 thousands, Surabaya 1.7 thousands, and Makassar 0.8 thousands (Damanhuri, 2002). These numbers indicated the difficulty of solid waste management in the country. Based on the numbers, it is estimated that Indonesia needs 675 hectares of landfill in 2005, and 1,610 hectares in 2020. Judging by the availability of land in urban area, it might lead to a major problem.

Principles of urban planning play important roles in managing development problems. In the context of landfills, there is a need of integrated cross-regional management of urban planning. Through this method, environmental supporting ability of one region should be considered important. Location planners usually focused on housing, industrial, public domains, and other facilities, but landfills are often neglected. Methods of systematically selecting landfill area and knowledge of the landfill importance and side effects are the two lacking factors that indicated the source of the problem.

There are numbers of technology and instruments to help the policy makers to consider every aspect before issuing policies. Information Technology such as GIS (*Geographical Information System*) have changed the approach of decision making. This kind of technology should make it easier for a planner to plan, design, control, and assess the planning process.

This system might support the policymakers in deciding the location of the landfills. GIS is able to provide modeling, predictions, and situation planning of landfill area. GIS would not only support the decision-makings, it is also able to manipulate some problem scenario. Furthermore, GIS is available to be integrated to other techniques of decision making such as *Spatial Multi-Criteria Decision Making* (SMCDM) in order to assess the landfill candidates in Batam.

GIS helps planners to produce rational decisions faster and more economical. GIS might also be related to the long-term development planning due to its capability to store geographical data and land usage. Its capability and high precision to manage, manipulate, and analyze data might solve many developmental problems today.

1.2 Problem Statement

Some problem with the allocation, efficiency, and SNI criteria occurred due to the existing waste management and landfill allocation in Batam was done manually.

For instance, the airport and some residential area became polluted because the location was too close to the landfill, the routes for the transport vehicles were considered not efficient. This study is applying network analysis in GIS to the better landfill location, which follows the criteria in SNI 03-3241-1994 and proven to be more efficient and economical.

1.3 Purpose of the Study

This study meant to apply Network Analysis in GIS to develop scenario generation model and assess alternative landfill sites in Batam City based on the economical aspects; such as to suggest more efficient routes for transport vehicles, while keeping the location of the landfill match the criteria on SNI 03-3241-1994. Moreover, the best route to achieve the closest landfill. Results of this study might help the government of Batam City to consider about the landfill projects in the city.

1.4 Objectives of the Study

Objectives of this study are as follows:

- i. to identify the existing waste management system in Batam City.
- ii. to identify criteria of landfill location based on GIS standard.
- iii. to provide and design GIS data model to produce some scenario alternatives of landfill locations.
- iv. to identify the best alternative location out of several generated alternatives based on economical factor, network analyzed by GIS.

1.5 Scope and Limitation of the Study

Scope and limitations of this study are as follows:

1.5.1 Scope

- i. Landfill location in this study was identified based on the quantitative aspects of economical.
- ii. Generated scenario was used to identify the best alternative of the future landfill location of Batam.
- iii. A model scenario for future appropriate landfill site was developed; the characteristics of the site in the scenario should fulfill the criteria of Indonesian National Standard (INS) or SNI (Standar Nasional Indonesia) no 03-3241-1994.
- iv. Scenario generation has done by using overlay process. This study used and manipulated secondary data from the database to analyse the alternative locations based on the fixed criteria by applying GIS analysis module such as ArcInfo.
- v. Network Analysis process was used to assess the most appropriate alternative location.

1.5.2 Limitation

- i. This study would only assess in main land of Batam
- ii. This study did not include industrial or hazardous wastes.
- iii. This study would only include pickup from transfer points.
- iv. This study would only employ existing algorithm in the ArcInfo-GIS.

1.6 Study Area

Batam archipelago includes 6 major islands: Batam, Rempang, Galang, Galang Baru, Bulan, Kapala Jeri, and approximately 400 small / minor islands, and only 329 of those small islands acquired their names. The land area is as wide as 1,038.4 squarekilometers and the waters are as wide 2,951,5678 squarekilometers. The study area was the island of Batam, which equals to 30% of the overall Batam.

The data obtained were analyzed by utilizing ArcInfo-GIS with Dijkstra Algorithm, and produced the results such as the landfill alternative locations, coverage area of the landfill alternatives, and the most efficient routes.

1.7 Importance of the Study

In the mean time, government agencies in Batam are not familiar to the application of GIS in term of waste management, especially about allocating landfills. The advantages of using GIS and its capability of forecasting future problems and their solutions would be introduced to the government in order to enhance the quality of decision-making process, especially about area planning. BAPPEDA (Planning and Development Board) would be supported by the application of GIS, especially in predicting the future problem solving and landuse planning.

This study would also introduce alternative quantitative methods that provide clearer justifications to support the decision makers to assess every aspect in order to give the best solution alternative.

1.8 Organization of Research

This research has arranged activities based on the objective. Chapter 3 would describe the process clearer and more detailed. There were some important stages in research implementation, namely:

- i. Issues and problems identification.
- ii. Literature study

- iii. Setting a purpose, objective and study scope
- iv. Research methodology and Data Collection
- v. Analysis, Discussion and conclusion

Every stage has distinctive activities. At the early stages, the researcher was identifying issue and problems in waste management. Through the problem discussion and literature study related to the goals and objective of the study specified. Study scope was set to make sure that the output could reach the aim and proposed objective.

The next level is to develop a study methodology to achieve the research goals. Model analysis was formed and further database development carried out for analysis was conducted. Network Analysis techniques will be applied in GIS environment.

Results of the analyses showed several alternative locations for landfill, which fulfill the criteria proposed. Furthermore, each of the alternatives would be analyzed by using Network Analysis to generate the best location based on economical aspects.

1.9 Summary of the Chapters

Briefly, this paper contains seven chapters. These chapters were developed based on each step described in the previous section. Chapter 1 introduced the current situation regarding to the solid waste and landfill issues that led to the problem statement, purpose, objective, scope, and area of the studies.

Chapter 2 discussed about related literatures about waste management, the importance of the landfill proper location and the criteria set in the SNI #03-3241-1994 and Undang-Undang RI No. 18 tahun 2008 about waste management.

Chapter 3 was described about the literature reviews of GIS and Network Analysis approach in assessing and location selection.

Chapter 4 was about the development of the database and the profile of the study area. Current existing data were described and elaborated in this chapter.

Chapter 5 described about analytical design and scenario generation modeling for the proper landfill locations using GIS based on the development potential of each location. Model development using Network Analysis was applied in this chapter. This chapter included required data for developing the model, site alternative nominating process, and the best alternative site nominating process.

Chapter 6 discussed about the identification of the alternative sites for landfill. Several locations scenario would be assessed by using Network Analysis in order to get the most appropriate landfill location in Batam based on the indicators and criteria.

Chapter 7 concluded and discussed the summary about the results acquired from the analysis.