Application of Geographic Information System (GIS) in Routing for Delivery of Fresh Vegetables
(Study Area of Kuala Lumpur & Klang Valley, Malaysia)

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Abstract—In recent years, issues for distribution of fresh vegetables become important concern for markets where their income is strongly depends on demand for more fresher production. The focus of this study is more on delivery of fresh vegetables in selecting the best routes particularly for urban area such as Kuala Lumpur city which is facing with the traffic problem. This research will conduct a company as a case study which is producing all kinds of fresh vegetables. This company is interesting in reducing their total distribution cost based on total travelled distance and total length of drive time. For this research needs to apply the GIS (Geographic Information System) technique. This technique is the respond for requirements of this research by using the network analyzing.

Keywords- Distribution; Fresh vegetables; Distance; GIS; Supermarkets

I. INTRODUCTION

It is accepted that distribution problems are currently one of the most important problems that both, public and private companies have to face day to day. The distribution problems are normally described as Vehicle Routing Problem (VRP) [1]. This issue is very critical especially for companies which are involved in the delivery of goods, where their income is strongly depended on how distribution problems are solved. Therefore, it is crucial for companies to be able to perform the tasks as efficiently as possible. The advance in the technological development provides one avenue in solving the distribution problems, where these tasks may be performed with the aid of computerized systems as in [1]. This study adopted the GIS (Geographic Information System) technique in determining the most optimal routes on the delivery of fresh vegetables to the selected hypermarkets in Klang Valley and Selangor. This technique would be able to help producers of fresh vegetables to effectively manage the delivery of their production by assisting them in selecting the optimal routes.

A. Objectives

The main aim of this study is applying GIS technology in determining the suitable routes based on the shortest distance and finally to propose a model to reduce the overall distribution cost for fresh vegetables. The objectives are as following:

1. To develop a spatial database management system for analyzing the Data
2. To propose a GIS model for distribution problem

B. Problem Statemen
t

Because of the traffic condition in recent years and the perishable nature of fresh food such as vegetables, selecting the optimal routes for reducing the travel distance would help to preserve the nutritional value of vegetables as in [2]. Preserving the nutritional value leads to have a better cost effective result and finally will affect the total distribution cost as in [6]. Here also have to be mention about the price of petrol which is increasing every day, and brings more attention to this factor, especially the private sector that is interested in determining which route is the best in saving time and cost. For the Sime Fresh Company the study case in this research reducing the distribution cost based on the total distance travelled by vehicle is important factor.

C. Contribution of This Research

The reviews of extant literature reveal that various studies have been conducted in the past on the distribution of fresh foods in various field of study. Osvald [6] has a research on a vehicle routing algorithm for the distribution of fresh vegetables and similar perishable food. To minimize the overall distribution cost, the objective function must not only model the number of vehicles, the total distance-traveled and the total travel-time, but additionally the loss of quality of the load. Belenguer [1] has created a computer package to design dispatching routes in the meat industry.

But the current research is conducting in Geographical perspective. The weaknesses for all of the various studies in the past are not adopting spatial data and the output of their studies is not performing types of map. The visualization for this kind of study is the new method to performance the best routes in the form of maps. According to Han [3] visualization helps people approach problems in the dimensions of space and time.
in the forms of map instead of dimensionally-restricted data tables and graphs.

The advantage of this research is to adopt the GIS technology in selecting the set of routes to fulfill the research objectives.

II. LITERATURE REVIEW

Osvald [6] has been focused on the distribution of fresh vegetables in which the perishability represents a critical factor. This paper presents a model for the representation of the loss of quality and considers it as part of the overall distribution costs.

Belenguer [1] presents a computer program that has been developed to design the delivery routes of a medium-sized meat company in Spain. The problem was solved by a number of heuristic algorithms.

Tarantilis [8] analyzed the distribution of the fresh milk. The problem was formulated as a heterogeneous fixed fleet vehicle routing problem which means different capacity. Minimize the total cost of delivering fresh milk is the aim.

In the field of civil engineering, as in [4] has a project on transportation management system. The objective of this thesis is to find out the optimal routes in a complex road network in the aspect of time, length and speed. Transportation cost is not considered as total distribution cost to offer the set of routes.

Shamsudin [7] conducted a thesis on transportation optimization model for palm oil. He developed an integer mathematical programming models to solve the crude palm oil (CPO) and the palm kernel (PK) transportation problems for northern peninsular Malaysia. Objective is to minimize the distance in optimal transportation.

A. Database Management System

Database management system is comprised of a set of program that provides facilities to manipulate and maintain the data in the database.

Fig 1, considers about the data input and the data output in GIS. After inputting and collecting the non-spatial data, it will be stored in attributes table in ArcView GIS software. With the combination of the road network layer as a spatial data and the non-spatial data which can be retrieval later, the data will be analyzed and the result is the output of the alternative scenarios for solving the problem by using the DSS tool.

B. Two Components of GIS Database

- Spatial data component; It consists of maps and which have been prepared either by field surveys or by the interpretation of remotely sensed data. Some examples of the maps are: soil survey, geological, land use, village. Many of these maps are available in analog form and recently some other map’s information is available directly in digital format as in [5].
- Non – Spatial data component; It consists of attributes as complementary to the spatial data. Attributes describe what is at a point, what about along a line or in a polygon and as socio – economic characteristics form census and other sources. The attribute of socio–economic category could be demographic data, or traffic volume data of roads in a city as in [5].
C. Equations
One of the main objectives of this research is to minimize the distance during distribution of fresh vegetables.

\[ \text{Min} = \sum \text{Length of distance} \]

III. METHODOLOGY
It provides an overview and discussion on how the research is designed and the choice of methods adopted for gathering and analyzing data in this research.

A. Location of Study
The study area for this research is a place for producing fresh vegetables. The name of the place is Sime Aerogreen Technology Sdn Bhd, which is located in SEREMBAN, Negeri Sembilan, Malaysia.

This research focuses on the main hypermarkets which is located in Selangor. The aim of this research is also to select the optimal route between the SIME FRESH and the main hypermarket destinations. The name of hypermarket which is focusing in this study is:

1- Carrefour

B. Data
According to the research objectives and requirement for this thesis, the data that must be collected for selecting the optimal route for delivery of fresh vegetables includes in the following table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spatial Data (Feature)</td>
</tr>
<tr>
<td>1</td>
<td>Base Map</td>
</tr>
<tr>
<td></td>
<td>• Road Network</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Land use Map</td>
</tr>
<tr>
<td></td>
<td>• Market location</td>
</tr>
</tbody>
</table>

Following table is the result of data collection and the source of the data.

<table>
<thead>
<tr>
<th>No.</th>
<th>Spatial data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theme of spatial data</td>
</tr>
<tr>
<td>1</td>
<td>Road Network</td>
</tr>
<tr>
<td>2</td>
<td>Land use Map</td>
</tr>
<tr>
<td>3</td>
<td>Market Location</td>
</tr>
</tbody>
</table>

C. Data management and Analysis
In order to make the decision for solving the problem of distribution based on the information on parameters, it needs to manage the existing information. The figure 3 is showing the process on how the available parameters in this research are involving in the model.
IV. CONCLUSIONS

Following figure is showing the best routes for distribution of fresh vegetables based on meters. For the first scenario it is considering about the main hypermarkets and distribution of fresh vegetables from the main source for producing fresh vegetables (number 1) to be delivered to the selected Carrefour (number 2 & 3) in this study. ArcGIS software combines with database management system as an integrated collection of data and information in this study has calculated the best routes based on distance for delivery of fresh vegetables to the Carrefour hypermarkets (2 & 3).

As it is showing in the following fig 5 the total distance is about 18324 meters for delivery of fresh vegetables to both Carrefour number 2 and 3.

In the second scenario if the company decides to distribute to only one Carrefour hypermarket then the data input in to the system is different and the result is based on decision making from producers of fresh vegetables for best distribution. The result for the second scenario is the best routes for distribution based on meters to only one Carrefour hypermarket (number 3) as following fig.

The following fig is showing the total distance in meters to Carrefour hypermarket number 3.

Comparing the both scenarios which is number one and two for calculating the distance; if the aim is to distribute to both Carrefour supermarkets then the calculation on figure 2 would be the best decision for producer of fresh vegetables to select. But if the aim is necessarily to distribute the fresh vegetables to only one Carrefour which is number 3 then the best calculation will be the figure 6 according to decision makers. For this reason the total distance is reduced and the vehicle will spend less time to reach to destination so the total distribution cost will increase.
ArcGIS Software with extension of Network Analyst is the primary key to explore the data. This research demonstrates how ArcGIS is a useful tool for decision maker to find the optimal routes for distribution of fresh vegetables.

GIS capabilities allow the user to create maps, showing the created maps, showing the data and integrate them and finally see the data in powerful new ways. ArcGIS enables to propose the research attractively. It can be found that communicating geographically is a powerful way to inform and motivate others.

The output of the study is producing the various kinds of maps showing the optimal routes for best distribution based on requirement of the study.

The visualization for this kind of study is the new method to performance the selected set of delivery routes based on digital maps. Network analysis in GIS is often used to find solutions related to distribution problems by using vector model to represent the real world.

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REFERENCES