Multi Depot Vehicle Routing Problem and Geographical Information System Integration: Retail Stores Case Study

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Abstract. The improper delivery route planning of multi depot and delivery assignment model leads the logistic operation in high travel distance and high distribution cost. This paper aim to explain the integration of multi depot vehicle routing problem (MDVRP) and Geographical Information System (GIS) to obtain the optimum delivery route planning with minimum travel distance by using multi-objective mixed integer programming approach and visualize its delivery assignment with open-source public GIS integration. In this research, the coordinate location of the depots and the retail stores are obtained, process the raw data through mathematical programming, then integrate the delivery plan to GIS for vehicle routing visualization. To validate the proposed model, the primary data of a retail stores chain was used and the model was evaluated with sensitivity analysis, resulted optimum value of total travel distance in daily logistic operation.

1 Introduction

Supply chain management (SCM) helps members of the chain to handle the flow of goods, reduce the costs and synchronize supply with demand. In the past decades of globalization, the world's indicator for international logistic and supply chain management is defined as the Logistics Performance Index (LPI). The index is developed to support identify the hardships and chance they experience in their effort on trade logistics operations [1]. However, Indonesia Logistic and Forwarders Association reported that the total logistic cost compared to Growth Domestic Product (GDP) is decreased. It was assumed at 21.0% for 2019; thus, the forecast of the Indonesian contract logistic market shows the linear incremental of Compound Annual Growth Rate (CAGR) 11.70% for the forecast period of 2013 to 2017 [1].

The sustain growth of the global logistics network incriminates a considerable degree of risk due to the profound investments and volatile demand patterns [2] furthermore, the logistic system has played an ever-growing and critical role in daily economic live. The logistics cost is an important factor that affects the price of products and is the biggest obstacle for the users of the logistics services industry. Actually, recent research data reported that poor material management increased the project duration by 50%-130%

Reflecting to Indonesia's logistic cost compared to GDP and logistic's critical role in daily economic live, it is important to do improvement for logistic performance, one of the way is to uplift the delivery planning method of an organization which having multi depots and daily logistic activities to ensure its business sustainability. With the minimum distribution cost, the cost of goods sold (COGS) could be minimized to strengthen the organization's competitive advantage in the market. The logistics cost is an important factor that affects the price of products and is the biggest obstacle for the users of the logistics services industry. Unsavory material management prolongs the duration of the project by up to 50%-130% [3] and been analyzed as one of the ordinary factors towards low productivity [4]. It was declared that averagely 30% of manpower productivity could be lost due to a shortage or materials out of stock [5].

Vehicle Routing Problem (VRP) has large area of implementation, from non-profit organization in government to the public sector. For example, the Capacitated Vehicle Routing Problem (CVRP) on tsunami disaster preparation in Phuket, Thailand [6]; the employee transportation problem [7]; and the integration of GIS with Multi Criteria Analysis (MCA) on energy sector [8]. This paper will observe further development based on mathematical model adopted from [9] with GIS integration on top of mathematical modeling as a part of its result visualization. To address this, this paper integrates MDVRP and GIS in a supply chain operation. The main contributions of this research are as follows:

- Applying open-source public GIS integration to MDVRP, using populated longitute and latitude of the depots and customers, optimize its route, and visualize the vehicle route assignment using GIS.
- Developing the delivery planning model to obtain the optimum route with minimum travel distance.

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- Solving the proposed model and visualize its vehicle assignment using GIS.
- Applying the proposed model in the case of retail business supply chain.

2 Literature Review

The VRP concept have been presented by Dantzig and Ramser when they implemented the mathematical programming formulation with the algorithm approach to solve the distribution problem of gasoline to the service stations. To solve this problem, the VRP method was developed to minimize the logistic transportation cost. VRP is mentioned as the task of devising delivery routes to serve certain customers in a supply chain environment. The problem apprehends the core of vehicle allocations and routes with minimum costs on a given distribution demand. Therefore, effective and efficient logistics management is very important.

The process for considering fleet routes and sequences results the option of multiple customer combinations in specifying the transport route for each fleet owned as well as criteria given and to accommodate many logistic business process features. Furthermore, the vehicle routing problem is a combinatorial optimization issue where the number of viable solutions to the problem increases exponentially with the sum of served customers. Vehicle Routing oncoming is to result ways out to the fleet routing [10]. Balanced Allocation Vehicle Routing Problem (BAVRP) main concern is the optimal and balanced allocation of customer requirement related to warehouse space and capacity, and also fleet routes for goods transporting from the initial depot to the assigned customer's facility. BAVRP was formed when designed a streamlined logistics, transportation, and distribution network between a manufacturer and customers group through several distributors. BAVRP is used for three ultimate headings: (i) logistics network that must be cost-efficient, means that the maximum distribution costs to each distributor are lessen to a minimum one, (ii) the material flow assignment in the transportation network must be as fair and balance as possible, therefore no single depot is underutilized or over-loaded, and (iii) the level of customer delivery service in the logistics network must be maintained at an acceptable form, so that the maximum fleet route distance and travel time from each distributor to its customer must be lessen into a minimum value.

This paper integrates the Balanced Allocation Problem with a Multi Depot Vehicle Routing Problem (BAMDVRP). In a BAP, conditions of the fair assignment of a customer groups to the depot's capacity are taken to the account [2]. Thus, the BAP is a variant of the classic issue where locations are given and solve a priori. Furthermore, BAP is an NP-complete problem [11]. In conclusion, MDVRP is an extended feature of the VRP with multiple depots.

The research by [12] emphasizing in multi-depot open vehicle routing problem concept, using the iterated local search algorithm method, another research by [13] introduces the new VRP variant of Vehicle Routing Problem With Time Window and Flexible Delivery Locations (VRPTW-FL). Next research from [14] presented open vehicle routing problem problem with capacitated constraints and travel distance.

[15] introduced the new variant of MDVRP, which was asymmetric MDVRP with multiple constraints e.g. time windows, working duration, vehicle capacity, and fleet size. [16] introduced a bi-level optimization for critical depots in vehicle routing context, modeled as attacker-defender game in r-interdiction selective multi depot vehicle routing problem (R1-SMDVRP). [17] applied hybrid ant colony algorithm to solve MDVRP with combining both probabilistic and exact techniques. [18] considered a homogeneous fleet of vehicles. [16] addressed a trilevel optimization problem for the protection of depots of utmost importance in a routing network against an intelligent adversary and formulated the problem as a defender-attacker-defender game and refer to it as the trilevel r-interdiction selective multi-depot vehicle routing problem (3LRI-SMDVRP). [19] proposed a two-commodity flow formulation for the MDVRP considering a heterogeneous vehicle fleet and maximum routing time. [20] proposed a cost effective learning-based heuristic technique to minimize the routing cost along with the potential cost due to the risk of vehicle breakdown and cargo delivery failure. [21] combined MDVRP and close–open mixed vehicle routing problem (COMVRP), assuming that the fleet of vehicles is heterogeneous.

[22] described a problem of optimal agricultural land treatment using aviation, they studied problem consists of determining the optimal routes for a given set of aircraft used for chemical treatment. [23] paper added solution with an Ant Colony System-based metaheuristic and an important constraint, vehicle capacity to the model, closer to real-world case of Multi Depot Green Vehicle Routing Problem (MDGVRP). [24] developed a multi-depot green vehicle routing problem (MDGVRP) by maximizing revenue and minimizing costs, time and emission, and then, apply an improved ant colony optimization (IACO) algorithm that aims to efficiently solve the problem. [25] studied MDVRP that considers the management of the vehicles and the optimization of the routes among multiple depots. They appled the artificial bee colony (ABC) algorithm to the MDVRP. [26] presented genetic algorithm-based approaches for solving the problem and compare the results with the hybrid clustering based genetic algorithm. [27] presented a simheuristic framework combining Monte Carlo simulation with a metaheuristic algorithm to deal with the stochastic multi depot vehicle routing problem (SMDVRP) with limited fleets. [28] proposed an improved harmony search algorithm for solving this problem. [29] presented the MDVRP based on customer's satisfaction (MDVRPCS). Since MDVRPCS is an NP-hard problem so, ant colony optimisation (ACO) has been proposed to solve the MDVRPCS.

[30] studied MDVRP with simultaneous deliveries and pickups (MDVRPSDP), this article presented a hybrid metaheuristic which combines simulated annealing (SA), ant colony optimisation (ACO) and along with long-arc-broken removal heuristic approach

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for solving the MDVRPSDP. [31] presented a complete multi-phase intelligent and adaptive transportation management system, which includes data collection, parameter tuning, and the heuristic algorithm based on the Tabu search for vehicle routing. The paper described the procedure for collecting Global Positioning System (GPS) data. [32] proposed the design of an intelligent decision system where the proposed system gives users the opportunity to solve the problem of VR with Time Windows (VRPTW) which is a generalization of the construction of vehicle routing problem. [33] solved the MDVRP using genetic algorithm approach with relying on operators as mutation, crossover, and selection. Primary focus of this work is to find efficient solutions for MDVRP within acceptable time frame.

Furthermore about integration with GIS, [34] used the linear programming and geographic information system (GIS) analysis to determine the best route. [35]; identified the integration between Modular Integrated Construction (MIC) with logistic planning and visualization of GIS and Building Information Modelling (BIM) as as a solution to project deployment of high-density city with model conversion usage. Research by [36]; did the analysis of city logistic centre in Istanbul with the integration of GIS and Binary Particle Swarm Optimization (BPSO) algorithm. Another literature from [7]; proposed the integration of GIS, metaheuristic algorithm, and optimation model to solve employee transporation problem to fix the route planning and vehicle assignment in order to do cost minimazion. Research by [37]; defined the VRP as spatial problem and proposed that the decision making of this scoop needs the integration of GIS and optimation method (GIS-O) with multi-step approach to solve Distance Capacitated Vehicle Routing Problem (DCVRP). Research by [38] using Mixed Integer Linear Programming (MILP) based on Path Based Approach (PBA) with variable of total distance with several differ route combination. [39] described the innovative application of machine learning techniques and delivery history obtained through a GPS vehicle tracking system for a more accurate estimate of unloading time. [40] proposed a two-step systematic approach to analyze municipal solid waste collection (MSWC) with ArcGIS. [41] proposed a methodology for routing collection vehicles in the twin cities (i.e. Islamabad and Rawalpindi) of Pakistan.

With mentioned literature review, this paper has the similarity of applying mathematical programming technique to solve the raw data of MDVRP, and using the coordinate location resulted from GPS, also the integration and visualization of GIS to BIM. The difference of this paper is, GIS to mathematical programming-based as a technique to solve the problem is integrated, with main contributions of this research are as follows: (1) applying open-source public GIS integration to MDVRP concept; (2) developing the delivery planning method to result the optimum route with minimum travel distance; (3) solving the proposed model and visualize its vehicle assignment with GIS, and (4) applying the proposed model in the case of retail business supply chain.

3 Research Method

This research was carried out following research method as mentioned in Figure 1. The research began by introduction that underlies why the research is conducted, the importance of the research, and state the problem definition to obtain the research contributions. In the next step, related basic theory was gathered and previous research are reviewed, then propose the integration model of MDVRP and GIS. This paper implements the model with primary data collected from a retail stores logistic business process using populated longitute and lattitude according to the depots and stores addresses. The data is processed and evaluated with sensitivity analysis to obtain the discussion, resulting multiple choice of research parameter leads to effective and efficient result subject to resources that organization deal for. Primary data are collected such are the location of the depot and the stores, logistic resources are defined with considering available vehicle owned per depot, daily stores requirement in volume, and the depot and vehicle capacity. The addresses then being populated using GIS to define the longitute and lattitude, become an input for depot balanced allocation to generate the vehicle route optimization using the mathematical model. After the optimized result been generated, GIS integration is performed to visualize the vehicle assignment into the maps.

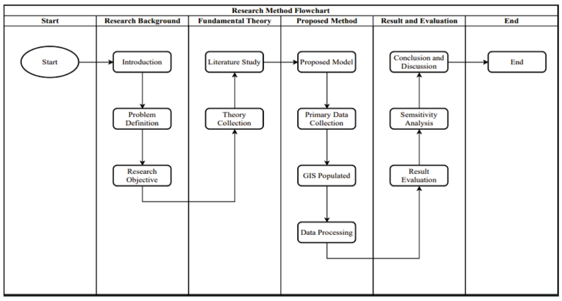

Fig. 1. Research Method Flowchart

3.1 Proposed Mathematical Model

Nodes C symbolizes n customers, D is referring m(k= 1, 2, …, m) depots, and E is set of edges symbolizes the connection from customer i to depot k or from customer i to j(i, j∈C∪D, i≠j;k∈D). Each customer i(i∈C), is served by properly one depot k(k∈D). On every edge (i, k), (i∈C, k∈D), there is a weight wik related to the cost of transportation between the customers and the depots. At every customer i(i∈C), customer requirement is mentioned as di, and at every depot k, capacity is stated as qk. every depot k(k∈D), owns properly one vehicle vk. Every vehicle vk has a route Rk serving various customers associated to the depot k, starting from the appropriate depot k, and the vehicle returning to the initial depot. All i(i∈C) customers are mandatory to be served, and every of them is served by properly one vehicle. The total demand of the served customers on every route Rk is not overloading the vehicle capacity gk. At the distance traveled from customer i to customer j(i, j∈C∪D, i≠j), disj is calculated from the customers' coordinate location, the customers' requirement di, the total capacity of the depot qk(k∈D), the total capacity of the vehicle gk(k∈D), and the decision variables xik and xijk. Therefore xik, xijk is valued = "1" if customer i, j is nominated to depot k, and else, valued as "0". The BAVRP used to conclude certain depot will accommodate customer needs based on arrangement of customers' requirement between the depots as balanced as possible and resulting the trajectory on each fleet to cut the mileage of each customer.

The mentioned formulation have the objective function (1) that minimizes total transportation costs, while arrange the demand at each depot as effective, and while nominating the minimum and maximum objective as the minimum and maximum assigned operator. The objective function (2) minimizes the total trajectory for all vehicle, in fact, each vehicle owned by each depot travels each of its customers once and then start over to origin depot. Constraint (3) arranges the total customer's requirements won't exceed the total capacity of the available depot. Constraint (4) arranges every customer is served by only one dedicated depot. Constraint (5) sets each customer is served once by each fleet. Constraint (6) arranges each route is fulfiled by maximum one fleet. Constraint (7) ensure that the same fleet in and out an assigned customer. Constraint (8) is the limit of the capacity on each fleet. Constraint (9) mentions each vehicle vk minimum serves one route that visit customer then leaves each customer's node. Constraint (10) reflects that each customer arranged to one depot is served properly once by each vehicle. Constraint (11) represents the assignment solution. xik= "1", if and only if the customer i is assigned to depot k (i∈C, k∈D); and else, valued as "0". Constraint (12) binary requirement on the decision variables that arrange the routing solution such xijk = "1", if and only if customer j immediately precedes customer i on route Rk(i, j∈C∪D, k∈D); and else, valued as "0".

$$\min \max_{k=1,\ldots,m} \sum_{i=l}^{n} d_i w_i x_{ik} \quad (1)$$

$$\min \sum_{i \in Customer \cup Depot} \sum_{j \in Customer \cup Depot} dis_{ij} \sum_{k \in Depc} \quad (2)$$

$$subject\ to: \sum_{i \in Customer} d_i x_{ik} \leq q_k, \forall k \in \text{ Depot} \quad (3)$$

$$\sum_{k \in Depot} x_{ik} = 1, \forall i \in \text{Customer} \quad (4)$$

$$\sum_{i \in Customer \cup Depot} \sum_{k \in Depot} x_{ijk} = 1, \forall j \in \text{Customer} \quad (5)$$

$$\sum_{i \in Customer} \sum_{j \in Depot} x_{ijk} \leq 1, \forall k \in \text{Depot} \quad (6)$$

$$\sum_{j \in Customer \cup Depot} x_{ijk} = \sum_{j \in Customer \cup Depot} x_{ijk}, \forall k \in \text{D}, i \in \text{Customer} \cup \text{ Depot} \quad (7)$$

$$\sum_{j \in Customer} d_j \sum_{i \in Customer \cup Depot} x_{ijk} \leq g_k, \forall k \in \text{ Depot} \quad (8)$$

$$\sum_{i \in S} \sum_{j \in S} x_{ijk} \leq |S| - 1, \quad \forall S \subseteq \text{Customer}, |S| \geq 2, k \in \text{Depot} \quad (9)$$

$$x_{ik} \sum_{j \in Customer \cup Depot} X_{ijk}, \quad \forall i \in \text{Customer}, k \in \text{Depot} \quad (10)$$

$$x_{ik} = 0\ or\ 1, \forall i \in \text{Customer}, k \in \text{Depot} \quad (11)$$

$$x_{ijk} - 0\ or\ 1, \forall i, j \in \text{Customer} \cup \text{Depot}, k \in \text{Depot} \quad (12)$$

4 Result & Analysis

Resolve a BAMDVRP issue in an organization is very promising. Forming an unified platform for the algorithms, mathematical model, data sources, and visual representation of the results is complex and demands comprehensive resources. Some of those resources that need to be integrated, such are a geological code system that functions to determine and obtain an actual address into the appropriate latitude and longitude coordinate and a mapping system that functions to determine travel time and actual distance between two given points and direction under the condition. Table 1 shows detail of the parameters for the VRP solver. In the term of location, the number of depots and number of customers (stores) become the important parameter, meanwhile the distance computation method, duration computation method, and average vehicle speed contributes to the distances paramater, and the vehicle capacity contributes to vehicles term that used in the respective case study.

Table 1. VRP Solver Parameter

Term	Parameter	Value
Locations	Number of depots	2
	Number of customers (stores)	40
Distances	Distance computation method	Bing Maps driving distances (km)
	Duration computation method	Average vehicle speed
	Average vehicle speed	40 kilometers per hours
Vehicles	Number of vehicle types	one type (CDE)

Table 2 shows the respective stop counts and its detail. For example, Depot A address is at Jl. Raya Jonggol - Cileungsi No.47 and its populated longitute is 106,96814 and latitude is -6,40656 (the detail for all depots and customers are given in the Appendix section). The requirement of each depot is provided, involving the data of vehicle types, vehicle capacity, work start time, driving time limit, work time limit which are presented in Table 3. For example, Depot A has 4 vehicles of CDE that has the 8 CBM capacity each, with work start time is 04:00, driving time limit is 09:00 and work time limits is 10:00 in hour.

Table 4 shows the distance and duration of the “from” as departure point and “to” as arrival point, for example, from Depot A to Customer 1, takes 36.50 kilometers of travel distance and 00:54 hout of travel duration.

With data presented from Table 2, Table 3, and Table 4, the BAVRP solution system generate the optimum route selection as shown in Table 5. The stop counts would refer to the sequences of departure and arrival point of the assigned vehicle 1, which departed from Depot A to Customer 39 with 32,006 km travel distance. Vehicle 1 carried 8 CBM when left the Depot A and drop 1 CBM in Customer 39 as “delivery amount”, then, left the Customer 39 with 7 “load balance” and depart to Customer 12, sequentially till achieve Customer 6 as last customer and go back to the Depot A. The solution is presented graphically in Figure 2, suggesting an intuitively acceptable solution and better visualizaton of each assigned vehicle routing.

Table 2. Address and Coordinate Mapping

Name	Address	Longitude(x)	Latitude(y)
Depot A	Jl. Raya Jonggol - Cileungsi No.47	106,96814	-6,40656
Depot B	JL Raya Perancis No. 2 Blok CD No. 8-9,	106,69094	-6,09532
Customer 1	Plaza Indonesia 1st floor # 160	106,82284	-6,19076
Customer 10	Jl. Asia Afrika lot.19 Jakarta 10270	106,7981	-6,21972

Table 3. Distribution Parameter Address and Distance Hour Mapping

Depot	Vehicle	Work start time	Driving time limit	Work time limit
A	4 CDE / 8 CBM	4:00	9:00	10:00
B	4 CDE / 8 CBM	4:00	9:00	10:00

Table 4. Address and Distance Hour Mapping

From	To	Distance (Km)	Distance Duration (Hour)
Depot A	Depot A	0.00	0:00
Depot A	Depot B	60.67	1:31
Depot A	Customer 1	36.50	0:54
Depot A	Customer 10	35.15	0:52

Table 5. Distribution Result Parameter for Vehicle 1

Stop count	Location name	Distance travelled (Km)	Delivery amount (CBM)	Load Balance (CBM)
0	Depot A	0	0	8
1	Customer 39	32.006	1	7
2	Customer 12	36.748	1	6
3	Customer 10	37.518	1	5
4	Customer 11	39.704	3	2
5	Customer 6	39.704	2	0
6	Depot A	74.901	0	0

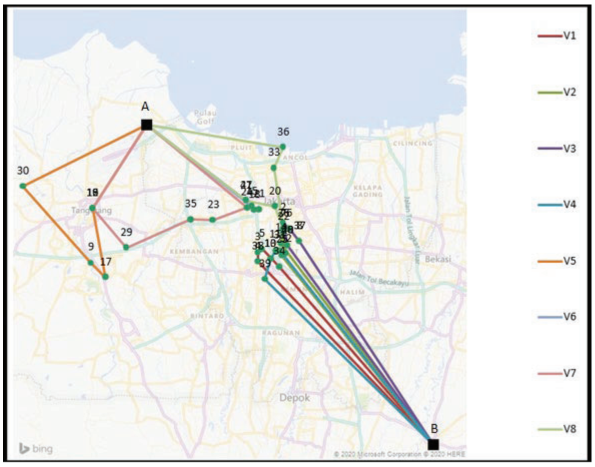

Fig. 2. The Proposed Optimum Route Selection

Figure 2 shows the visualisation result of the eight vehicles routing. Node A shows the first depot location and node B shows the second depot location. The number 1 to 40 indicates the location of retail stores or customers (see appendix for detail information) that supplied from Depot A and Depot B. This result are generated from the mathematical model, with the output of vehicle routing assignment from each depot to several customers.

The results summary are provided in Table 6, which indicates each vehicles delivery assignment with each vehicle’s distance travelled, departed and arrived as a sequential order. As shown in Table 6, Vehicle 1 departed from Depot A, then travelled to Customer 39, to Customer 12, to Customer 10, to Customer 11, to Customer 6 and go back to Depot A with 260,58 KM distance travelled. Departed from Depot B, Vehicle 5 travelled to Customer 19, to Customer 25, to Customer 23, to Customer 16, to Customer 35 and go back to Depot B with 185,86 KM distance travelled.

Table 6. Vehicle to Customers Sequential Route

Vehicle	Depot	Sequential Route of Customers	Distance Travelled (KM)
V1	A	Customer 39 - 12 -10 - 11 - 6 - Depot A	260,58

V2	A	Customer 20 - 28 -14 - 37 - 30 - Depot A	258,82
V3	A	Customer 5 - 15 -13 - 1 - 33 - 8 - Depot A	298,82
V4	A	Customer 36 - 18 - 2 - 17 - 7 - Depot A	251,81
V5	B	Customer 19 - 25 - 23 - 16 - 35 - Depot B	185,86
V6	B	Customer 21 - 27 - 24 - 32 - Depot B	144,9
V7	B	Customer 22 - 34 - 4 - 29 - 3- Depot B	244,02
V8	B	Customer 40 - 38 - 31 - 26 - 9 - Depot B	228,25

For the analysis section, sensitivity analysis are performed and necessary to find the best possible solution so that the result could reach a much more acceptable performance options in facing real-world difficulties. Change in the vehicle owned of each depot and vehicle capacity has impacted different results on the objective functions impacted, such are:

- The number of vehicle used.
- The number and the sequence of customer that each assigned vehicle are routed.
- The total travel distance that each assigned vehicle are routed.

At the beginning, four vehicles for Depot A and four vehicles for Depot B with each of its vehicle capacity of 8 CBM are used to do the calculation, and with the change of vehicle owned and the change of vehicle capacity, the outcome are shown in Table 7, Table 8, Figure 4 and Figure 3.

Table 7. Change of Vehicle Capacity With Four Vehicle Owned per Depot

Vehicle	Travel Distance (in KM)		
	Capacity = 8	Capacity = 9	Capacity = 10
V1	260,58	291,13	424,86
V2	258,82	262,74	256,01
V3	298,82	332,12	303,69
V4	251,81	345,49	0
V5	185,86	187,06	279,27
V6	144,90	154,97	88,89
V7	244,02	60,73	221,57
V8	228,25	208,29	215,39
Total	1873,05	1842,53	1789,69

Table 8 shows the parameter with total vehicle owned is four vehicles per depot, and then compared to vehicle capacity 8 CBM, 9 CBM, and 10 CBM. The result shows Vehicle 1 travelled 260,58 KM with vehicle capacity 8 CBM, travelled 291,13 KM with vehicle capacity 9 CBM, and travelled 424 KM with capacity 10 CBM.

As a total of 8 vehicles travel distance, vehicle capacity 8 CBM travelled 1873,05 KM, vehicle capacity 9 CBM travelled 1842,53 KM, and vehicle capacity 10 CBM travelled 1873,05 KM with only 7 assigned vehicles required.

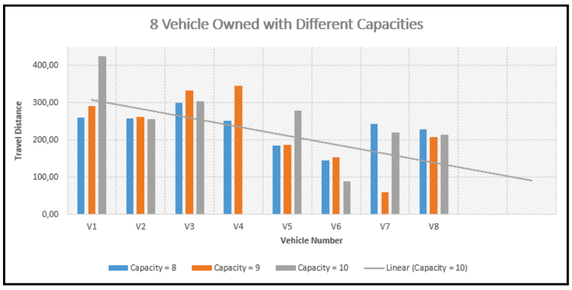

Fig. 3. Total Distance Graph of Vehicle Capacity With Four Vehicle Owned per Depot

Figure 3 shows the visualization of Table 6 and indicated down trendline of total travel distance on vehicle capacity 10 CBM. With vehicle capacity 10 CBM, the total travel distance is 1789,69 KM and required only 7 vehicles, better than vehicle capacity 9 CBM that resulted 1842,53 KM and 8 vehicles required, and also better than vehicle capacity 8 CBM that resulted 1873,05 KM and 8 vehicles required.

Table 8. Change of Vehicle Capacity With Three Vehicle Owned per Depot

Vehicle	Travel Distance (in KM)		
	Capacity = 16	Capacity = 14	Capacity = 10
V1	502,30	385,37	343,13
V2	0,00	456,88	327,87
V3	0,00	0,00	387,87
V4	536,80	279,27	279,27
V5	484,19	253,12	215,88
V6	324,80	356,30	214,87
Total	1848,08	1730,94	1768,89

Table 8 shows the parameter with total vehicle owned is three vehicles per depot, and then compared to vehicle capacity 16 CBM, 14 CBM, and 10 CBM. The result shows Vehicle 1 travelled 502,30 KM with vehicle capacity 16 CBM, travelled 385,37 KM with vehicle capacity 14 CBM, and travelled 343,13 KM with capacity 10 CBM.

As a total of 6 vehicles travel distance, vehicle capacity 10 CBM travelled 1768,89 KM, vehicle capacity 14 CBM travelled 1730,94 KM with only 5 vehicles required, and vehicle capacity 16 CBM travelled 1848,08 KM with only 4 vehicles required.

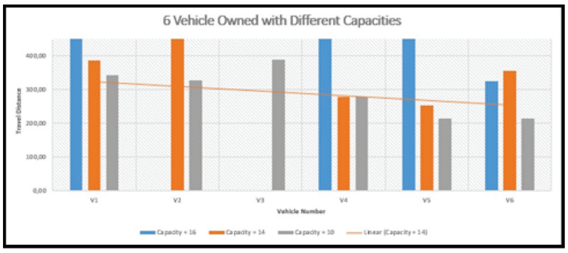

Fig. 4. Total Distance Graph of Vehicle Capacity With Three Vehicle Owned per Depot

Figure 4 shows the visualization of Table 8 and indicated down trendline of total travel distance on vehicle capacity 14 CBM. With vehicle capacity 14 CBM, the total travel distance is 1730,94 KM and required only 6 vehicles, better than vehicle capacity 16 CBM that resulted 1848,53 KM and 5 vehicles required, and also better than vehicle capacity 10 CBM that resulted 1768,89 KM and 6 vehicles required. If the organization concern to shortest travel distance, the vehicle capacity 14 CBM could be considered, but if the organization concerned more to number of required vehicles, then vehicle capacity 16 CBM should be considered.

These scenarios could give a multiple choices for the organization to perform their experimental design to result the effective and efficient logistic operations, according to the organization purposes and management goals, available resources, and another constraints such as permitted vehicle size in certain city to do daily activities, working hours, and or adjusting to the next customer's logistic business process to utilize the resouce at its best. Number of vehicle owned and vehicle capacity change could impact different result and the organization could be able to have multiple options to perform the best alternatives.

One thing that could also be changed is the number of depots involved. With the addition of number of available depots, the optimized result could also make different impact of total travel distance and number of vehicles required. This consideration needed to be aligned with organizational resource and capability.

5 Conclusion

This research built a system for solving BAMDVRP issue, combining several platforms for data sources, solution algorithms, and resulting visual representation. The results shows for 8 vehicles route, and for conclusion, vehicle 1 through Depot A – Customer 39 – Customer 12 – Customer 10 – Customer 11 – Customer 6 – Depot A with 260,58 distance unit travelled as the result and as an answer to the problem definition. The result shows the contribution of this paper, which are applying open-source public GIS integration to MDVRP, developing the delivery planning model to result the optimum route with minimum travel distance, solving the proposed model and visualize its vehicle assignment with GIS and applying the proposed model in the case of retail business supply chain. Through this proposal, we suggest an approach to consolidate those platforms into a cohesive system. It captures the essence of allocation and routing of vehicles at minimum cost, given logistic demand, which is crucial to effective and efficient logistics management.

The suggestion for further research is to develop the model with more scenarios the organization has. Some have problems in one single depot, another may have problems in time-window wise, and another may have problems in multi delivery with pick up and backhaul, and capacitated depot and or split delivery model. Moreover, the usage of different GIS platform such as QGIS could also be considered and real-time delivery tracking should be implemented to control the operation reliability. There are so much more scenarios are available for further study and development to support and obtain organization's logistic operation excellence and supply chain sustainability.

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