APPLICATION OF LOCATION ROUTING PROBLEM USING SPATIAL DATA ON FOOD DISTRIBUTION AND EVACUATION OF GRESIK FLOOD DISASTER

Artya Lathifah, Renny Sari Dewi
Universitas Internasional Semen Indonesia

Abstract
In recent years, humanitarian logistics has attracted much attention due have contributed a lot in helping and saving human life. In this research will be developed mathematical model of Location Routing Problem that applied using spatial data for flood disaster in Gresik, East Java, Indonesia. The purpose of the model to be developed in this research, is to minimize the time of sending aid to the victim by determining the most efficient location of aid post and the route of the food distribution. The vehicle that used, must be matched with the real condition. Determination of the location of post and route of vehicle decided by the number of victims based on the location of the house, travel time, the number of people and the amount of aid needs. The complexity of the problem will be solved using metaheuristic method. The algorithm will be developed into a user-friendly web-based application that integrated with Spatial Data on Google Maps API to obtain more accurate data on disaster location. Therefore, at the end of the research is expected to be able to answer the challenge of humanitarian logistics for flood disaster that occurred in Gresik. This will be shown in the form of application that can be used by government to facilitate the distribution of logistic aid.

Introduction
In recent years an increase in the number of natural disasters and man-made disasters has caused damage in many places and cost many human victims of injuries, starvation to death (Nathan and Gerald, 2012). A disaster can be categorized as a natural disaster when the disaster occurs in an area that has a population and leads to destruction of local infrastructure and causes the population to diminish and suffer (Costaa et al., 2012). Like the earthquake that occurred in Haiti in 2010 and the earthquake / tsunami and nuclear disaster that occurred in Japan in 2011, these disasters show the vulnerability of developed countries as well as emerging countries to disaster (Nathan and Gerald, 2012). Therefore, a good response to the possibilities of the disaster that will occur and also the response to the disaster that has occurred. A possible response to the disaster will be by undertaking plans related to the anticipation, mitigation, and management of the consequences that may be caused by the disaster. While the response to the disaster that has occurred is related to the response to the current situation that occurred in the disaster area and action related to the situation. Humanitarian operations are indispensable in situations in pre-disaster, during disaster and post-disaster. Humanitarian operations include saving the wounded, collecting corpses, allocating resources, providing and organizing the provision of food, shelter, medical care, restoring transportation access and so on. These humanitarian operations must be performed effectively and efficiently as they relate to human safety. The field that studies matters related to humanitarian operations is the humanitarian supply chain.

Humanitarian supply chain is different from commercial supply chain. In the corner of the supply chain the supply chain connects the source of the supply (supplier) to the owners of demand (end customer). The main purpose of the supply chain is to deliver the right amount of products, the right time and the right location (Chandraprakaikul, 2010). The supply chain consists of all activities and processes related to the flow and transformation of finished goods from raw materials to end users (Beamon and Balcik, 2008). Meanwhile, the humanitarian supply chain is related to the supply flow through the relief chain from donation to the consumer. The difference between commercial supply chain and humanitarian supply chain is described in Table 1.

Chandraprakaikul (2010) says that Oloruntoba and Gray (2006) in his journal explain that humanitarian supply chains tend to be unstable. Thus, coordination and management of the disaster supply chain is urgently needed and should be within the humanitarian supply chain. Goals, revenue sources and performance measures of the humanitarian and commercial supply chain have distinct differences. Humanitarians do not have specific profit targets and sources of funding come from governments and donors. The goal of a humanitarian supply chain is to respond to multiple interventions in the shortest possible time in a short-time frame.

Topic	Commercial SCM	Humanitarian SCM
Main Objective	Maximize profit	Save lives and help beneficiaries
Demand Pattern	Fairly stable and can be predicted with forecasting techniques	Irregular with respect to quantity, time and place. Demand is estimated within the first hours of response
Supply Pattern	mostly predictable	Cash is donated for procurement. Unsolicited donations and in-kind donations need sorting, prioritizing to decrease bottlenecks
Flow Type	commercial products	resources like evacuation vehicles, people, shelter, food, hygiene kits, etc
Lead Time	mostly predetermined	approximately zero lead time, demand is needed immediately
Delivery network structure	established techniques to find the number and locations of warehouses, distribution centres	Ad hoc distribution facilities or demand nodes, dynamic networrk structure
Inventory control	safety stocks for certain service levels can be found easily when demand and supply patterns is given	unpredictable demand pattern makes inventory control challenging. Prepositioned inventories are usually insufficient
Technology and information systems	highly developed technology is used with commercial software packages	Less technology is used, few software packages that can record and track logistics data. Data network is non-existent
Performance measurement method	based on standard supply chain metricks	Time to respond the disaster, fill rate, percentage of demand supplied fully, meeting donor expectation
Equipments and vehicles	ordinary trucks, vehicles and forklifts	robust equipment are needed to be mounted and demounted easily
Human Resources	commercial SCM is now a respected career path (Thomas, 2003)	High employee-turnover, based on voluntary staff, harsh physical and psychological environment
Stakeholders	Shareholders, customers and suppliers	Donors, governments, military, NGOs, beneficiaries, United Nations, etc

Table 1: Perbandingan antara Commercial dan Humanitarian Supply Chain Management (Ertem et.al, 2010)

In this research will be made web-based application of Location Routing Problem for flood disaster case in Gresik regency. According to the official site of Gresik regency government, some areas in Gresik Regency have the potential to experience annual floods such as Benjeng, Cerme, and Balungpanggang. The relief vehicles will take aid in the form of food and medicines in the donation post and then distribute it to aid posts in several sub-districts. Assistance to be distributed to relief posts consists of many types of goods. The amount of each type of goods distributed depends on the number of victims by age and sex in the destination aid post. So did not rule out every aid vehicle distribute the type of goods with the same amount. If a victim has to be moved to a safer place or hospital then a relief vehicle will take the victim to the destination. The purpose of the model to be developed in this research is to minimize the time of delivery of assistance to the victim, so as to minimize the response time of handling the flood victims and maximize the number of victim handling in the existing relief facility with the constraints that have been determined. Determination of the location of the post and the route of the relief vehicle considers the number of casualties and assistance needed based on the travel time of the relief delivery region. Because the combination is complex, then in this research will be developed Simulated Annealing (SA) algorithm which is metaheuristic method. The algorithm will be developed into a user friendly application and integrated with Spatial Data from the Google Maps API to obtain more accurate data on disaster locations. So hopefully at the end of this research will be obtained a Multi Products Location Routing Problem application integrated with Google Maps that provide results in accordance with actual conditions and able to answer the challenges of humanitarian logistics for floods that occurred in Gresik.

Literature Review

Routing Problem in Humanitarian Logistics

Last Mile Distribution Problem (LMDP) is the final stage of the humanitarian relief chain. This is related to the delivery of relief supplies from local distribution (LDCs) to recipients or victims from affected areas (Beamon et.al, 2008). The research conducted by Beamon et al. 2008 is to allocate relief supplies to LDCs that lie between demand locations and determine delivery schedules for each vehicle through planning horizon based on supply, vehicle capacity and delivery time in order to minimize transportation costs and maximization benefits to aid recipients. However, this research still requires development for problems with more complex conditions. Özdamar and Demir (2011) conducted research also related to this issue however, not only the problem of distribution problem but also the pick-up problem. So that not only distribute relief supplies but also take into account the ways of evacuation of victims both in terms of routes, schedules and capacity of the vehicle. Azimi et.al (2011) conducted a study which was a generalization of the covering tour problem that focused on determining the location of satellite distribution centers (SDCs) so that they could reach the optimal distance either by refugees, vehicles from the depots that supply relief supplies using vehicles and capacities which is diverse. Multi-start heuristic used in this study resulted in high quality and realistic solutions in adequate computation time. Campos et.al (2012) created a heuristic algorithm model that can generate 2 evacuation routes with minimal travel time and minimization of transport network only. Chang et.al (2007) conducted a study related to the model against flood prevention. In principle not much different from similar research. However, this study in addition to using stochastic programming but also combine with geographical information system (GIS). Rottkemper et.al (2011) makes the transshipment model for the distribution and relocation of inventory in the uncertainty state with the objective of minimizing unsatisfied demand and operational cost. This study takes account on the penalty cost resulting from unsatisfied demand. Wohlgemuth et.al (2012) examines the related activities of pick up and delivery problem (PDP). Research aims to find solutions related to PDP problems by avoiding delay and increasing utilization of equipment. However, this study only focuses on relief goods.

Furthermore, Huanga et.al (2011) conducted a study related to the formulation of efficacy and equity and showed that there is a significant difference between solutions focusing on efficiency and equity and focusing on traditional commercial concern of efficiency. Research conducted by Hamedia et. al (2012) focuses on reliable routing and scheduling of humanitarian supplies with time-dependent networks. Sugiarto et al (2015) conducted facility research for flood disaster in Gresik Regency. In this research, GIS has not been used as a support tool so that the data obtained is more accurate so that the depot specified can really meet the needs of disaster victims.

Location Routing in Humanitarian Logistics

Problems relating to the determination of the location of the supply goods so that it can optimally reach out and can distribute the aid effectively and efficiently in operations - humanitarian operations into a new field of research from the field of humanitarian supply chain which is different from the commercial supply chain. Such as research conducted OnurMete et.al (2009) that do the stochastic optimization approach to the problem warehousing and distribution of medical supplies for disaster. Stochastic programming determines the optimal warehouse location at the inventory level in the first stage. While in the second phase of the determination of transportation plans which are then converted into optimal vehicle route plan. Galindo and Batta (2012) conduct research related to the determination of the location of supply in hurricane disasters. An interesting point in the study is to include considerations regarding the locations of potential supplies that may be damaged. Thus, it is not only to determine the location but also to estimate the supply locations that will be affected by the hurricane. Spirit et.al (2013) conducts research that is still related to the determination of the location, ie warehouse. This study determines the factors that influence the selection of warehouse locations. The results of this study indicate that cooperation attribute is the most important-factor in the selection of the location of the warehouse in the humanitarian supply chain.

Simulated Annealing

Simulated Annealing (SA) is one of the metaheuristic methods often used to solve both discrete and continuous combinatorial problems (Gandreau and Potvin, 2010). Tavakkoli-Moghaddam et al. (2006) and Van Breedam (1995) used SA to complete the Capacitated Vehicle Routing Problem (CVRP) and VRP. Yu et al., (2010) uses SA to break another variant of VRP, the Capacitated Location Routing Problem (CLRP). This shows that SA provides a better solution than any other algorithm. SA has been used extensively in solving VRP problems, because SA has some interesting advantages such as the ability to handle highly nonlinear models, chaotic and noisy data and data that have many constraints. SA has been successfully applied in complex combinatorial optimization problems (Van Breedam, 1995; Yu et al., 2010). In addition, SA is one of the meta-heuristic methods that have successfully solved some VRPs (Alfa et al., 1991; Kuo, 2010; Lin et al., 2006; Van Breedam, 1995; Xiao et al., 2012).

Location Selection Requirement

Humanitarian logistics is defined as an effective and efficient planning, implementation, and control process from the relief center to the disaster site with the aim of reducing the suffering of disaster victims (Thomas & Kopczak [3]). Meanwhile, according to the Regulation of the Head of National Disaster Management Agency (BNPB) Number 14 of 2010 (BNPB, 2010), in determining the location of the most appropriate depot to cope with disasters are:

1. A large enough space that can accommodate several tents
2. Near to the main access road entering the disaster area
3. Near to the evacuation location
4. Location safe and free from disaster threats.

In this research we define the location is a place which has large yard and safe area. Therefore, we specify the location candidate or suggestion from Google API are worship place, village meeting hall, front yard of housing or esplanade.

Model Formulation

The formulation of this problem is using linear programming in model implementation the location of the postal allocation or aid depot has been used in the discussion (Kusumastuti, Wibowo, and Insanita) regarding the location of the facility aid of flood victims in Kampung Melayu, Jakarta East by using mathematical models. Model the location of this relief facility has some of the assumptions used. Besides it is stipulated in the budget of available fees, help requests, time periods, and more which will be described in the mathematical model as following.

$$\max \sum_{i \in I} y_i a_i \qquad (1)$$

$$s.t \sum_{i \in I} x_j \leq y_i \qquad (2)$$

$$\sum_{j \in J} x_j fv_j \leq bv \qquad (3)$$

The notations of the mathematical model are as following:
i : Request help materials on site evacuation
j : Potential location for relief facilities
t : Period of time
t_{max} : Maximum service time
x_j : 1, [if facility can be located for location j] 0, [if not]
y_i : 1, [if request for help in location i can filled] 0, [if not]
a_i : Estimated number of casualties on site demand i
bv : Budget costs
fv : Fixed costs
vf : Maximum number of places the facility can established

Mathematical model of location determination of annual flood disaster relief post in Gresik Regency, especially in Sub-district of Benjeng and Kecamatan Cerme limited by some constraints. This has been done by Sugiarto et al (2015) The constraints are the constraints of vehicles, time, and the number of requests for assistance. This mathematical model is a development of model by Sugiarto et al (2015). This formulation has a purpose function to minimize delivery time which will be explained as follows.

$$\min \sum_{i=1}^{n} t_{ij} x_{ij} \text{, where } [j = 1, \dots, k] \qquad (4)$$

$$s.t \sum_{i=1}^{n} t_{ij} x_{ij} \leq t_{max} \qquad (5)$$

$$\sum_{i=1}^{n} y_i - \sum_{j=1}^{k} = 0 \qquad (6)$$

$$\sum_{j=1}^{k} x_{ij} = 1 \text{, where } [i = 1, \dots, n] \qquad (7)$$

Notations of the mathematical model created are as follows.
i Number of requests for assistance at the disaster site
n number of node of demand that should be filled
k number of location available that can be opened
j Potential location of help post
t Period of time
*t*max Maximum service time
t_{ij} Transportation time from village of disaster location i to potential location *j*
x_{ij} 1, [if there is sending help from location *j* to i] 0, [if not]
x_j 1, [if potential location of help post open] 0, [if not]

<u>Numerical Experiment and Discussion</u>

Verification of the Model and Algorithm Applied in Spatial Data

The objective function and constraints of the mathematical model that have been made are then verified using LINGO 11 software. The distance that we used is the real time gotten from Google Maps API. The time that calculated in the Data assumed as the time travelled using vehicle that cannot run quickly. The tavel time setting was using formula written in https://www.quora.com/What-is-the-assumed-walking-speed-in-Google-Mapss-time-estimates. Figure 1 describe the data with two locations available and four demand nodes which represents the victims that should be served. The result using LINGO 11 is Location A – 381 – 380 – 383 – 382 – Location A and the total time is 1075s.

Figure 1: Display of the Test Data (2 available location, 4 demand nodes of the victim)

We use Simulated Annealing Algorithm to solve data. The algorithm is shown in Figure 2. The metaheuristic simulated annealing (SA) algorithm used is an adjustment of the algorithm found on the handbook metaheuristics by Gandreau and Potvin in 2010. The algorithm consists of two parts: the initial phase and the repair phase. Initial phase will be used Priciest Insertion to find the initial solution. After getting the initial solution, the algorithm is continued into the repair phase. In this phase, a new route selection will be made by randomly changing the neighborhood solution, such as swap, insertion, reverse move, and facility change.

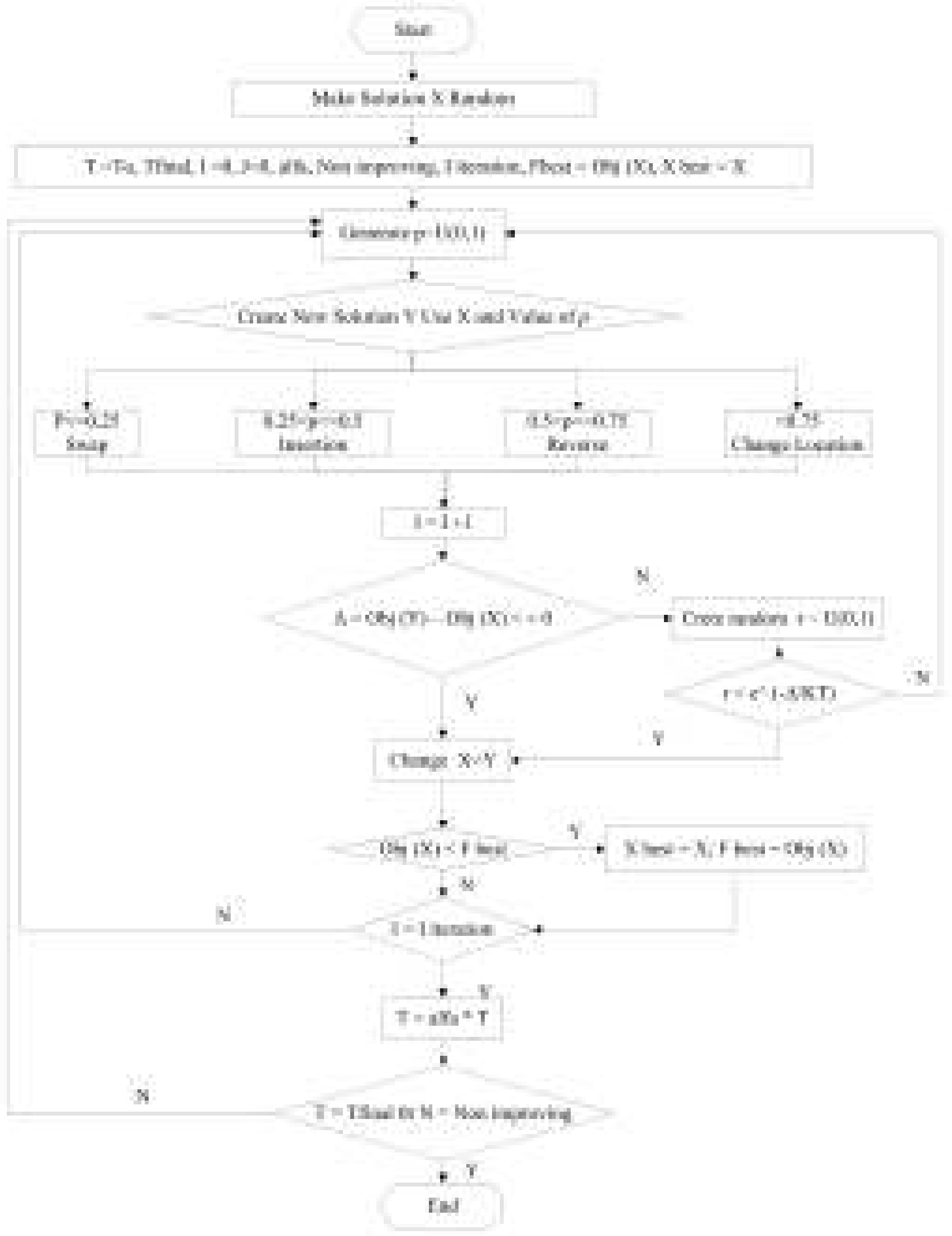

Figure 2: Simulated Annealing Algorithm

The algorithm starts with the current temperature setting, T_0 and randomly generates the initial solution *X*. The best solution is now denoted by X_{best} and the objective function of X denoted by F_{best}. The new solution denoted by Y, is the solution resulting from the previous solution improvement (X), each value of its objective function will be evaluated and compared. Let $\Delta = obj\ (Y) - obj\ (X)$. If Δ is less than or equal to zero, then the objective value Y is better than X, therefore X is replaced by Y. Otherwise, the possibility of replacing *X* with *Y* is $exp\ (\Delta\ /\ KT)$. X_{best} and F_{best} will record the best current solution and the best objective function value. The current temperature T0 will decrease after iteration using the formula $T = \alpha T$. The algorithm ends when the current T0 temperature is lower than T_{final} or the best solution currently

X_{best} is not repaired further as much as $N_{non-improving}$ in successive temperature reductions. In this research we use T_0 = 100, T_{final} = 10, α = 0.5, K = 1, and Iteration = 5.

Figure 3: The choosen Location and the route

Sayyid Abdurohman Worship Place --381--380--383--382-- Sayyid Abdurohman Worship Place = 1075s and total Travel Time: 1075s.
The results of LINGO 11 and SA algorithm are the same, it can be concluded that the SA algorithm applied to web-based application using Google Maps API has been able to find the same answer with exact method for cases with small area and small node.

Web-Based Application Display of Food Distribution for Flood Disaster Victims
This research is proposed to be done in collaboration with Gresik Regency Disaster Mitigation Agency. Therefore, Government can use this application to update the information in accordance with real conditions related to be more quickly and responsive in delivery of logistics assistance. Here is the main function of the web:

Figure 4: Main Menu of the Web

I. Home. The main menu, we could find the route including the total food distributed for each facility location in the specific area of the flood disaster.

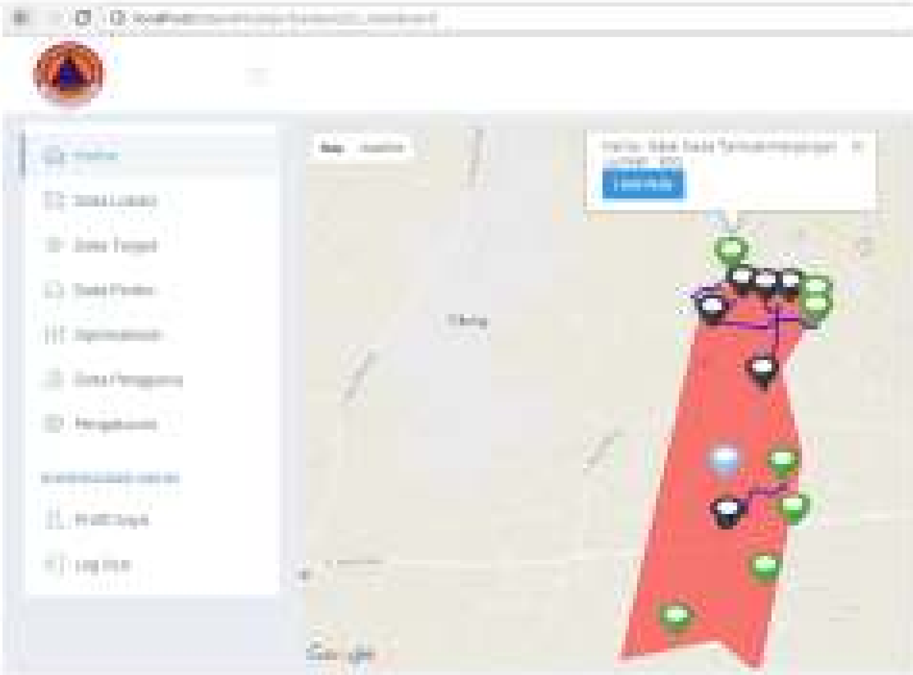

Figure 5: Home Menu

II. Data Target. In this menu, it is determined how many demand node and the location of the demand node (Black pins) respectively. It is also to determine how many aid that should be distribute. It is also a button "Hitung Jarak" for finding the time travel from and to each demand/victim node. This data is saved and then will be used in finding the route.

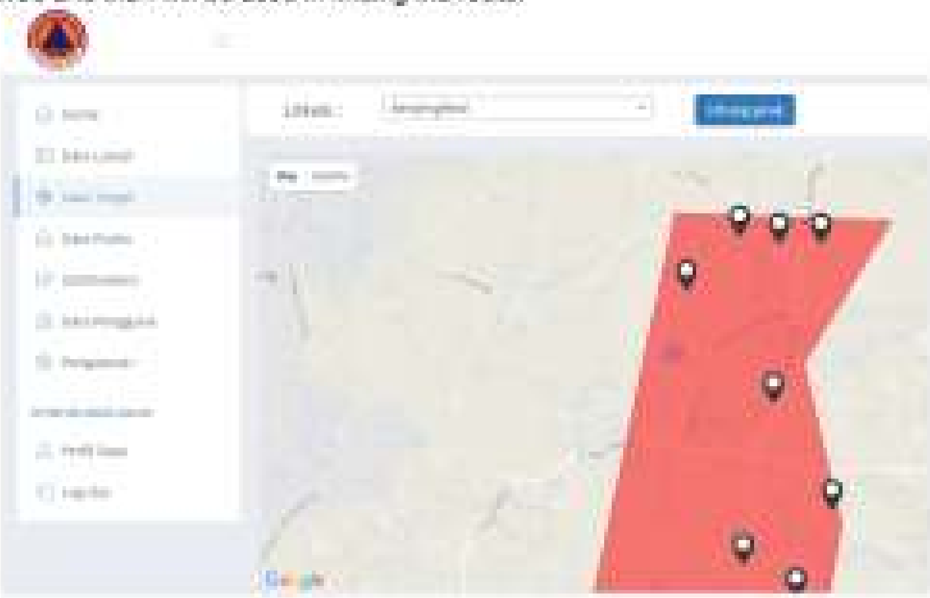

Figure 6: Data Target Menu

III. Data Posko. In this page, we could find the available locations (Yellow pins). Is is also a button "Cari Rute" to find the best location that should be open (Green pins).

Figure 7: Data Posko Menu

IV. Optimalisasi. In this menu, Simulated Annealing algorithm is applied. It is also available button for user to change the parameter of the Simulated Annealing. We could see the initiation solution until the final solution. Then, after it is done we could see the result of the route in the Home menu.

Figure 8: Optimalisasi Menu

V. Pengaturan. We can change the safe area and the t_{max} that we will use.

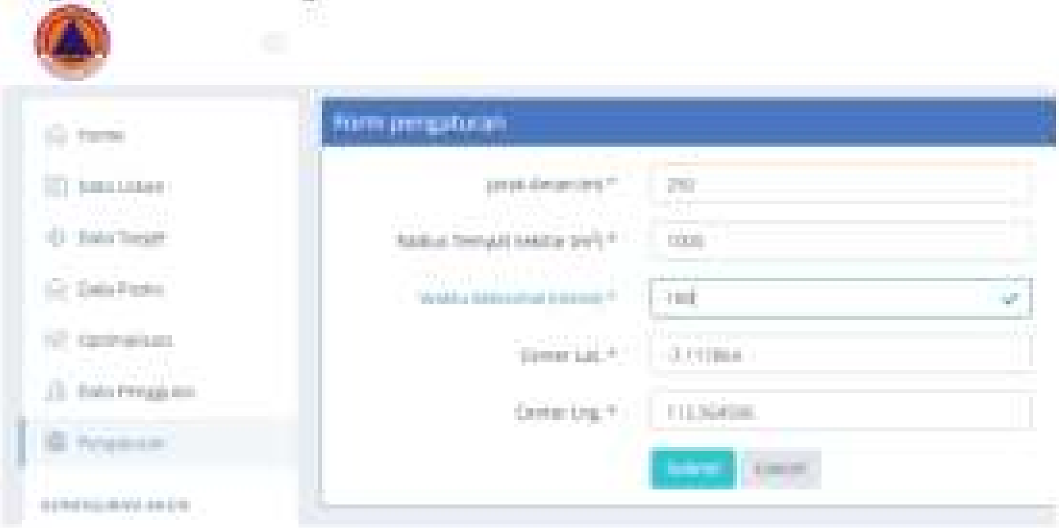

Figure 9: Pengaturan Menu

Numerical Experiment of the Locations Routing Problem using Web-Based Application for Food Distribution for Flood Disaster Victims

The data that input to the application is based on Sugiarto et al (2015) for Cerme and Benjeng Area and dummies for Balung Panggang Area. The differences between this research and the previous research is the web-based application that refers to real condition instead of linier programming which using assumed distance matrix.

Here is the available facility location that meet the requirements:

Locations Available Cerme	Locations Available Benjeng	Locations Available Balungpanggang
AL Hidayah	Baiturrohim	Jamik
Al Abror	AlMuhlisin Gredek	Al Mukaromah
Al Fajar	Roudotus Salam	At Taqwa
Baitur Rohim	Balai Desa Tambakrejo	Roudhotul Jannah
Sirojul Mukminin	AL Ikhlas	Banjaragung
Hidayatullah	Sirojul Mujahidin	Babus Salam
Al Irsyad	AL Muttaqin	Al Muhajirin
Perum Menganti	AL Irsyad	Al A'lsa
Permata Indah	At Taqwa	
	Al Abror	

Table 2: Available facility Locations each Area

BENJENG DATA			CERME DATA			BALUNGPANGGANG DATA		
Demand Node	Food Package Needed	Code in Application	Demand Node	Food Package Needed	Code in Application	Demand Node	Food Package Needed	Code in Application
Lundo	171	344	Morowudi	1500	356	Ngasin	350	376
Balungtunjung	132	345	Iker-Iker Geger	985	361	Gonggang	580	373
Balongmojo	164	346	Cerme Kidul	150	360	BalungPanggang	1050	371
Balungkulon	123	347	Dungus	300	362	Karangsemanding	800	374
Sedapurklagen	790	348	Pandu	150	363	Wotan Sari	350	375
Deliksumber	900	354	Ngembung	120	365	Pucung	250	376
Kedungrangkem	53	350	Surangenpir	150	357	Pacuh	500	372
Munggugianti	900	351						
Bengkelolor	150	352						
Gluranploso	325	353						
Bulurejo	900	349						
Dermo	300	355						

Table 3: Demand Node, Food Pckages, and Code in Application

As shown in Table 3 the demand nodes and food packages for each of them is different. The coded of the demand node in application is needed due to make easier in calculation process. The determination of the demand node point uses Google Maps API. The result of optimization each area are shown in Table 4, Table 5 and Table 6

Initial Solution			
Location	Route	Time Travel (minutes)	Food Distributed
Baitunohim	345-353-354-346-347	39.703	1644
Balai Desa Tambakmenjangan	351-350	57.733	953
Al Ikhlas	352	78.120	150
Al Abror	349	97.807	900
Al Mukhlisin	344	103.960	171
Al Muttaqin	355	126.327	300
Sirojul Mujahidin	348	149.400	790
TOTAL TRAVEL TIME		**654.65**	**4908**
SA Result			
Location	Route	Time Travel (s)	Food Distributed
Baitunohim	345-353-354-346	31.610	1521
Al Mukhlisin	351-350-347	29.713	1076
Roudlotus Salam	352	20.387	150
Balai Desa Tambakmenjangan	349	19.687	900
AL Ikhlas	344	5.753	171
Sirojul Mujahidin	355	24.767	300
Al Muttaqin	348	21.073	790
TOTAL TRAVEL TIME		**152.99**	**4908**

Table 4: Result in Application for Benjeng Area

Table 4 shows the solution obtained from application. It is seen that the facility location should be open is 7 locations. The SA result shows some changes from initial solution, not only the route, but also the facility that opened which make the delivery time is minimize.

Initial Solution			
Location	Route	Time Travel (minutes)	Food Distributed
Perumahan Menganti Permata Indah	365-356-366	39.360	1770
Sirojul Mukminin	357-361	71.910	1095
Hidayatullah	362	88.763	300
AL Irsyad	363	140.397	150
TOTAL TRAVEL TIME		**340.430**	**3315**
SA Result			
Location	Route	Time Travel (s)	Food Distributed
Perumahan Menganti Permata Indah	356-361-357	25.937	2595
Sirojul Mukminin	365-366	16.920	270
Hidayatullah	362	16.853	300
AL Irsyad	363	51.633	150
TOTAL TRAVEL TIME		**111.343**	**3315**

Table 5: Result in Application for Cerme Area

Initial Solution			
Location	Route	Time Travel (minutes)	Food Distributed
Al Muhajirin	371-367-375	42.757	1650
Al A'laa	373	56.157	580
Banjaragung	372-374	88.490	1300
Mukaromah	376	123.650	250
TOTAL TRAVEL TIME		**311.053**	**3780**
SA Result			
Location	Route	Time Travel (s)	Food Distributed
Al Muhajirin	372-367-371	31.723	1800
Al A'laa	373	13.400	580
Banjaragung	374-375	9.980	1150
Babus Salam	376	35.160	250
TOTAL TRAVEL TIME		**90.263**	**3780**

Table 6: Result in Application for Balungpanggang Area

Table 5 and Table 6 show that by using Simulated Annealing can obtain better solution by change the different routes. It is also shows that the food packages all should be delivered. In Humanitarian Logistics the aid have to deliver to the victims.

	Initiation (min)	SA result (min)	% Improvement
Data Benjeng	654.650	152.990	76.63%
Data Cerme	340.430	111.343	67.29%
Data Balungpanggang	311.053	90.263	70.98%

Table 7: Comparison between Initial Solution and Simulated Annealing Result in Application for all Areas

Percentage of the improvement each calculation is using formula

$$\%improvement = \frac{(initiation - SA)}{initiation} x100\% \quad (8)$$

It is seen that the improvement of the result by SA contribute for more than 60% of minimizing delivery time.

Conclusion

We develop a web-based application of Humanitarian Logistics based on Location Routing Problem in Gresik, East Java, Indonesia which is very useful for government, and so the victims of the flood disaster. This research is proposed to be done in collaboration with Gresik Regency Disaster Mitigation Agency. Therefore, Government can use this application to update the information in accordance with real conditions related to be more quickly and responsive in delivery of logistics assistance. The result of Simulated Annealing run in the application obtained faster time travel delivery. This is needed by the Government to make decision not only the located should be open as a facility location of distribution centre but also the route.

Further research could consider wider and more demand node. The decision of the vehicle type and its capacity should be takes in to account. Parameter setting for the Simulated Algorithm also should be take into account to reach better perform of the algorithm.

References

- Afshar, A. Haghani, A. (2011). "Modeling integrated supply chain logistics in real-time large-scale disaster relief operations", *Journal of Socio-Economic Planning Sciences*, Vol. 46, pp. 327-338.
- Alfa, A.S., Heragu, S.S., Chen, M., 1991. A 3-opt based simulated annealing algorithm for vehicle routing problems. Computers & Industrial Engineering, Vol. 21, pp. 635-639.
- Azimi, Z.A. Renaud, J. Ruiz, A. Salari,M. (2011), "A covering tour approach to the location of satellite distribution centers to supply humanitarian aid", European Journal of Operational Research, Vol. 222. pp. 596–605.
- Balcik, B. Beamon, B.M. Smilowitz, K. (2008), "Last mile distribution in humanitarian relief", Journal of Intelligent Transportation Systems, Vol. 12, pp. 51–63.
- Campos, V. Bandeira, R. Bandeira, A. (2012), "A method for evacuation route planning in disaster situations", Journal of Social and Behavioral Sciences, Vol. 54, pp. 503 – 512.
- Chandraprakaikul, W. "Humanitarian supply chain management: literature review and future research", Department of Logistics Engineering, School of Engineering. University of the Thai Chamber of Commerce.
- Chang, M.S. Tseng, Y.L. Chen, J.W. (2007), "A scenario planning approach for the flood emergency logistics preparation problem under uncertainty", Journal of Transportation Research, Part E 43, pp. 737–754
- Chiang, W.-C., Russell, R.A., 1996. Simulated annealing metaheuristics for the vehicle routing problem with time windows. Annals of Operations Research, Vol. 63, pp. 3-27.
- Costaa, S.R.A.D. Camposb, V.B.G. Bandeira, R.A.D.(2012)," Supply Chains in Humanitarian Operations: Cases and Analysis", Journal of Social and Behavioral Sciences, Vol. 54, pp. 598 – 607.
- Ertem, M.A. Buyurgan, M. (2011), "An auction-based framework for resource allocation in disaster relief", Journal of Humanitarian Logistics and Supply Chain Management, Vol. 1 No. 2, pp. 170-188.
- Galindo, G. Batta, R. (2012), "Prepositioning of supplies in preparation for a hurricane under potential destruction of prepositioned supplies", Journal of Socio-Economic Planning Sciences,Vol. 47, pp. 20-37.
- Gendreau, M., Potvin, J.-Y., 2010. Handbook of metaheuristics. Springer.
- Hamedia, M. Haghanib, A. Yang, S. (2012), "Reliable Transportation of Humanitarian Supplies in Disaster Response: Model and Heuristic", Journal of Socio-Economic Planning Sciences, Vol. 54, pp. 1205-1219.
- Huanga, M. Smilowitza, K. Balcikb, B. (2011), "Models for Relief Routing: Equity, Efficiency and Efficacy", Journal of Procedia-Social and Behavioral Science, Vol. 17, pp. 416-437.
- Indonesia. Badan Nasional Penanggulangan Bencana. (2010). Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor 14 Tahun 2010 Tentang Pedoman Pembentukan Pos Komando Tanggap Darurat Bencana. Jakarta
- Kusumastuti RD, Wibowo SS, Insanita R. Relief logistics practices in Indonesia: a surv-ey. Proceedings of The 5th International Con-ference on Business and Management Resear-ch, Depok, Indonesia; (2010).

- Lin, S.-W., Ying, K.-C., Lee, Z.-J., Hsi, F.-H., 2006. Applying simulated annealing approach for capacitated vehicle routing problems, Systems, Man and Cybernetics, 2006. SMC'06. IEEE International Conference on. IEEE, pp. 639-644.
- OnurMete, H. Zabinsky, Z.B. (2009), "Stochastic optimization of medical supply location and distribution in disaster management", International Journal of Production Economics, Vol. 126, pp. 76-84.
- Ozdamar, L. Demir, O. (2011), "A hierarchical clustering and routing procedure for large scale", Journal of Transportation Research, Part E 48, pp. 591–602.
- Roh, S. Jang, H. Han, C. (2013), "Warehouse Location Decision Factors in Humanitarian Relief Logistics", The Asian Journal of Shipping and Logistics, Vol. 29. No.1, pp. 103-120.
- Rottkemper, B. Fischer, K. Blecken, A. (2011) "A transshipment model for distribution and inventory relocation under uncertainty in humanitarian operations", Journal of Socio-Economic Planning Sciences, Vol. 46. pp. 98-109
- Sugiarto, S, Widyayana, I.G.A, Octavia, T. "Model Matematis Lokasi Pos Bantuan Bencana Banjir Gresik". "Petra Jurnal Titra", Vol. 3 No.2, July 2015, pp. 265-268Tavakkoli-Moghaddam, R., Safaei, N., Gholipour, Y., 2006. A hybrid simulated annealing for capacitated vehicle routing problems with the independent route length. Applied Mathematics and Computation, Vol. 176, pp. 445-454.
- Tseng, Y.-y., Yue, W.L., Taylor, M.A., 2005. The role of transportation in logistics chain. Eastern Asia Society for Transportation Studies, Vol. 5, pp. 1657 - 1672.
- Van Breedam, A., 1995. Improvement heuristics for the vehicle routing problem based on simulated annealing. European Journal of Operational Research, Vol. 86, pp. 480-490.
- Wohlgemuth, S. Oloruntoba, R. Clausen,U. (2012), "Dynamic vehicle routing with anticipation in disaster relief", Journal of Socio-Economic Planning Sciences, Vol. 46, pp. 261-271.
- Xiao, Y., Zhao, Q., Kaku, I., Xu, Y., 2012. Development of a fuel consumption optimization model for the capacitated vehicle routing problem. Computers & Operations Research, Vol. 39, pp. 1419-1431.
- Yu, V.F., Lin, S.-W., Lee, W., Ting, C.-J., 2010. A simulated annealing heuristic for the capacitated location routing problem. Computers & Industrial Engineering, Vol. 58, pp. 288-299.
- Thomas, A., & Kopczak, L. R. (2005). From Logis-tic to Supply Chain Management: The Path For-ward in The Humanitarian Sector. Fritz Institut-e, San Francisco, CA.