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DEVELOPMENT OF ZERO ONE INTEGER PROGRAMMING MODEL FOR OPTIMIZING THE NUMBER OF AND LOCATION FIREFIGHTER STATION IN NORTH ACEH DISTRIC

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ABSTRACT

Fires is a disaster that happened unexpectedly and caused huge losses in the form of casualties' man and property. Fire is often unavoidable, which can be done is to minimize losses by establishing and providing firefighting facilities in the right area so as to reach the sub district center area in less than 15 minutes at the time of fire to extinguish the fire. At present North Aceh District has built 3 (three) fire stations to serve 27 sub-districts within its territory (Kantor Dinas Pemadam Kebakaran Kabupaten Aceh Utara). The existing fire stations are located in Alue Bili, District Nisam, District Landing Lhoksukon and Krung Mane, District Muara Batu. This study aims to determine the number and locations of the Optimal Firefighting Station within the district of North Aceh, which is a minimal number Stations but can reach all areas within the district of North Aceh. To achieve this goal, the method used is to model the problem into the Integer Zero-One programming model, then completed with TORA windows® version 1.00 June 2002 by Taha H.. The implementations of the models produce the optimal solution is the minimum number of fire stations that must be built in North Aceh Regency is 6 stations so it needs to be added 3 more stations, with locations in the sub-district: Baktiya, Banda Baro, Cot Girek, Geureudong Pase, Kuta Makmur and Syamtalira Aron.

KEY WORDS: Firefighters Station; Integer Programming; Zero-One , Optimalizing

INTRODUCTION

Fire is the most common disaster. Fire itself can be classified as a natural disaster or disaster caused by humans. Fire hazards can happen anytime, because many opportunities can trigger a fire. Therefore, fire disaster is impossible to avoid, but that can be done is to minimize losses due to the fire both losses due to casualties and losses due to the victim of property. Minimizing losses from fires can be done by establishing fire stations in certain places so as to provide fire extinguishing if the fire happens with a relatively short response time. Building fire stations and facilities will require considerable investment, so the number of fire stations built should be as minimal as possible but still capable of providing services with relatively sharp response time to any area with the potential for fire.

To minimize losses due to fire disasters in industrial environments, offices, housing and forests, it is necessary to provide firefighting facilities, The Government of North Aceh Regency which oversees 27 sub-districts currently has three fire stations located in Alue Bili, Nisam District, Landing Lhoksukon Sub District and Krung Mane, Muara Batu Subdistrict. The fire station is under the Regional Disaster Management Agency North Aceh district.. Besides it is also aided by government-owned facilities Firefighters Lhokseumawe who are in the middle of the North Aceh district as well as some of the facilities belonging firefighters fighting industrial company located in the district of North Aceh and Lhokseumawe. The extent of the area to be served, limited equipment and a location away from the fire station to the scene of the fire accident caused fire services are not in accordance with the predetermined response time .

Given the existence of firefighters is significant, fire hazards should be anticipated and addressed in a comprehensive, systematic, effective and sustainable preventive effort. One of the Fire Fighting efforts is setting up the location of the fire station. Faster or timely response to the site when a fire disaster occurs is needed so that the area of fire can be minimized. One of the efforts that firefighters can respond in a relatively short time if a fire at a location occurs is by placing the Fire Station as close as possible probably with fire location. The extent

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of potentially fire and stochastic areas requires proper planning of the number and location of the Fire Brigade. Firefighters, the smaller the Fire Deployment. Establishing the number and location of the fire station as an emergency response facility requires special consideration.

Based on the Decree of State Minister of Public Works No. 11 / Kept / 2000 on Technical Provision of Urban Fire Management, it is mentioned that the location planning of firefighting post within the Fire Management Area (WMK). WMK is determined on the basis of response time standards against fire notices in the region The response time to fire notification for conditions in Indonesia is no more than 15 (fifteen) minutes.

Therefore, on this occasion the researchers will conduct a study that aims to find out how many Fire Stations to be built in North Aceh District and anywhere construction site so as to provide optimal service, i.e. the number of stations to a minimum but able to reach the whole region within the district of North Aceh in a relatively short time.

LITERATURE REVIEW

Integer Programming

Integer Programming essentially deals with some or all variables having integer or discrete values. Common forms of Integer Programming models are:
Objective Function :

$$M \quad (m \quad)Z = \sum c_j x_j$$

Subject to :

$$\sum a_i \; x_j \; (\leq, =, \geq) \; b_i, \qquad (i = 1, 2, ..., m),$$
$$x_j \geq 0, \qquad (j = 1, 2, ..., m),$$

x_j integer value for some or all of j

All decision variables of the model at the top will have a non-negative value of the riel, such as fractions, decimals. Sometimes the decision variables must take integer values. For example, the number of workers, machinery and so forth. If we round off the optimum value obtained, the solution is not necessarily provide optimal results [3].

0 – 1 Integer Programming

Each variable integer can be expressed equally in the form of a variable number of zero-one (binary) pure. The simplest way to do this is as follows: Suppose 0 x ≤ n is an integer variable in which the integer n is the upper limit. Then, with a note that Y_1, Y_2, and Y_n is a zero-one variable.

$$X = y_1 + y_2 + \cdots + y_n$$

It is a definite binary representation of all the values of a decent x. A more economical representation in which the number of binary variables is usually smaller than n is known.

$$X = y_0 + 2y_1 + 2^2y_2 + \cdots + 2^k y_k$$

Where k is the smallest integer that satisfies $2^{k+1} - 1 \geq n$.

The fact that any integer problem can be binary simultaneously with simplification of calculations in

$$Min \sum_{j=1}^{n} c_j x_j \qquad (1)$$

$$subject\ to \sum_{j=1}^{n} a_{ij} x_j \geq 1, \qquad i = 1,...,m \qquad (2)$$

$$x_j \in (0,1) \qquad j = 1,...,n \qquad (3)$$

handling the zero-one variable (each variable has only two values) has drawn attention to the utilization of these properties to develop an effective algorithm.

Set Covering

Set Covering problem is a classical problem in computer science and complexity theory. Set covering problem is one of most important discrete optimization problem because it serves as a model for real world problems. Real world problems that can be modeled as set covering problem include facility location problem, airline crew scheduling, nurse scheduling problem, resource allocation, assembly line balancing, vehicle routing, etc. Set covering problem is a problem of covering the rows of an m-row/n-column zero-one matrix with a subset of columns at minimal cost. Set covering problem can be formulated as follows:

Equation (1) is the objective function of set covering problem, where cj is refer to weight or cost of covering j column and xj is decision variable. Equation (2) is a constraint to ensure that each row is covered by at least one column where aij is constraint coefficient matrix of size m x n whose elements comprise of either '1' or '0'. Lastly, equation (3) is the integrality constraint in which the value is represented as in (4).

$$x_j = \begin{cases} 1 & \text{if } j \in S, \\ 0 & \text{otherwise,} \end{cases} \qquad (4)$$

Even though it may seem to be a simple problem by judging from the objective functions and constraints of the problem, set covering problem is a combinational optimization problem. It has been proven to be NP-Complete decision problem [6 in 4]. A number of heuristic algorithms for set covering problem have been reported in the literature. Beasley, as one of main researcher in set covering problem had implemented several algorithms in order to solve set covering problem. Beasley presented an algorithm that combines problem reduction tests with dual ascent, sub-gradient optimization and linear programming. This algorithm had performed well in solving set covering problem [6 in 4]. It was able to find feasible optimal solutions for all set covering problem sets. In a different literature, Beasley presented a paper which used Lagrangian relaxation and

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sub-gradient optimization approach to solve set covering problem [7 in 4]. But this method did not perform well compared to his previous method. It was unable to find optimal solutions for several set covering problems such as SCP-4.4, SCP-4.6, SCP-5.1, SCP-5.2, SCP-5.7, SCP-6.1,SCP-6.5, etc. Haddadi presented a simple Lagrangian heuristic to solve set covering problem. The method is based on Lagrangian duality, greedy heuristic for set covering problem, sub-gradient optimization and redundant covers. This method had turn out to be efficient for low density set covering problem with a large number of variables with average deviation of 0.35%.

Beasley and Chu presented genetic algorithm for set covering problem [9 in 4]. They presented a new crossover-fusion operator, a variable mutation rate and a heuristic feasibility operator to improve the performance of genetic algorithm. This method performs well, for most of problems. Aickelin proposed an indirect genetic algorithm. The indirect genetic algorithm comprises of three phases. In the first phase, genetic algorithm finds good permutation of the rows to be covered. In second phase, a decoder build a solution from the permutations using the parameter provided. And lastly, in the third phase, a hill-climber optimization method is used.Indirect genetic algorithm is able to solve the set covering problem in shorter computational time. Monfroglio proposed a linear programming relaxation model and improvement techniques based on simulated neural network This method is able to find solutions within 0.2% of optimal solution and increase the overall computational time. Vasko and Wolf adapted heuristic concentration approach to solve the weighted (non-unicost) set covering problem. Their method is able to solve set covering problem and find solution with deviation of maximum of 3.27% from optimum solution.

Basic Theory of Set Covering Problem

Let (X, F) in the set covering problem consist of a given set X and a set F of subset X. We assume that each element X appears at least one of the subset F,[12]

$$X = \bigcup_{S \in F} S$$

The set S is said to close every element. The set covering problem asks us to specify the minimum size of the F subset that closes all the elements of X.

$$X = \bigcup_{S \in C} S \; a \quad |C| \; i: \; m$$

Suppose that in problem set covering as in figure 1 below, assume that the requested task is a set of skills, which we express p X. Every person who may potentially be selected to exist in the committee. Some are skill-set Sp ⊑X expertise. If we find F = Up Sp, then it is clear that the minimal set covering for this example (X, F) on the issue of covering appropriately set in accordance with the committee for the smallest number that can accomplish the task. S1, S3 and S4 is a cover of the set (set covering) and S2, S5 and S6 are closed by a sub-set of the set covering.[12],.

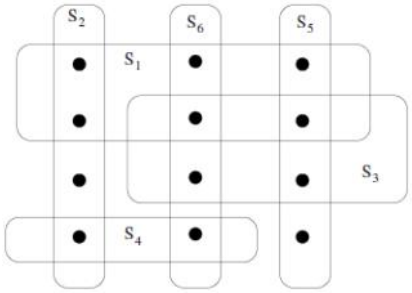

Figure 1: Examples of subsets closed by set covering

Study Methodology

The problem solving in this study is done by approaching Programa Integer Zero-One. The study steps under taken can be described as follows : :

1. Setting Goal Study Objectives
   The purpose of this study is to determine the number of Firefighters station and placement locations optimally so that it can reach all the areas with the potential of Firefighters disaster in North Aceh District.
2. Data Collection
   At this stage, data collection of profile and geographical location of North Aceh District, data of the number of sub-districts in the region and the travel time between sub-districts if the availability of direct transportation routes. This time travel data collection is done by utilizing Google Maps geographic information system. In addition to this also conducted the collection of existing data about the number and locations of existing Firefighters stations at the time of the study conducted.The geographical data of North Aceh District are as follows:

1) North Aceh District is a district located in the province of Aceh, Indonesia. The district's capital was moved from Lhokseumawe to Lhoksukon, following Lhokseumawe as an autonomous city. This district is classified as the largest industrial area in the province and is also classified as the largest industry outside Java, especially with the opening of liquefied natural gas processing industry PT. Arun LNG in Lhokseumawe in 1974. The following briefly described the profile of North Aceh district as follows [13] :
   a) Capital city : Lhoksukon
   b) North Aceh district, District of Bener Meria District in the south, west to the Bireuen district, adjacent to the northern borders of the Lhokseumawe City and the Strait of Malacca, the east by East Aceh district. 3
   c) Area: ± 3,296.86 km²
   d) Coordinate location: 96.52.00 ° - 97.31. 00 ° East and 04.46.00 ° - 05.00. 00 ° East
   e) Population: 572 961 Soul (2014)
   f) Sub-district: 27
   g) Number of settlements: 70

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h) Number of Villages: 852/0

2) Subsequently collected data of the number of sub-districts in the region and the travel time between sub-districts if the availability of direct transportation routes. This time travel data collection is done by utilizing Google Maps geographic information system. In addition to this also conducted the collection of existing data about the number and locations of existing Firefighters stations at the time of the study conducted.The geographical data of North Aceh District are as follows: Maps of North Aceh district as shown in figure 2 below:

Figure 1: Maps of North Aceh District (https://www.google.com/search?q=kabupaten+aceh+utara//

Sub-districts within the district of North Aceh, the number of settlement and number of villages (Gampong) within the district of North Aceh as shown in table 1 below:

Table 1: Sudistrict Names, Number of Settlements and village

No.	Subdistricts	Settlement	Village
1	Sawang	2	39
2	Nisam	3	29
3	Nisam Antara	1	6
4	Banda Baro	1	9
5	Kuta Makmur	3	39
6	Simpang Kramat	2	16
7	Syamtalira Bayu	4	38
8	Geureudong Pase	-	11
9	Meurah Mulia	3	50
10	Matang Kuli	4	49
11	Paya Bakong	4	39
12	Pirak Timu	2	23
13	Cot Girek	3	24
14	Tanah Jambo Aye	4	47
15	Langkahan	3	23
16	Seunuddon	3	33
17	Baktiya	3	57

Table 1: Sudistrict Names, Number of Settlements and village [13] (continued)

18	Baktiya Barat	3	26
19	Lhoksukon	4	75
20	Tanah Luas	3	57
21	Nibong	2	20
22	Samudera	3	40
23	Samudera Aron	4	34
24	Tanah Pasir	1	18
25	Lapang	1	11
26	Muara Batu	2	24
27	Dewantara	2	15

3) Travel time between sub-districts

The travel time between subdistricts is measured using google maps satelite with consideration of the availability of connecting roads that can be passed by 4 or more wheeled vehicles from and to the sub-district city within the district of North Aceh. The data of travel time from one sub-district to another sub-district in North Aceh Regency is presented in table 2 is below.

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Table 2: Travel time between sub-districts within North **Aceh district(in minute)** (based on google maps satelite)

From / To		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26	X27
Baktiya	X1	0	20	87	81	86	65	84	89	39	27	39	53	103	51	80	117	106	52	68	144	35	84	39	95	17	132	47
Baktiya Barat	X2	20	0	86	76	87	124	83	105	28	40	34	51	98	59	74	111	92	47	46	139	40	93	46	64	40	96	42
Banda Baro	X3	87	86	0	125	15	62	46	137	67	85	69	66	23	78	17	48	101	90	64	55	101	55	66	48	101	98	70
Cot Girek	X4	81	76	125	0	123	156	143	71	88	73	82	99	135	88	111	148	111	86	91	175	123	137	83	103	103	133	92
Dewantara	X5	86	87	15	123	0	76	54	136	66	84	68	53	21	65	18	55	101	89	50	72	100	56	53	48	102	84	57
Geureudong Pase	X6	65	124	62	156	76	0	42	182	122	116	124	109	67	121	73	24	136	124	106	54	132	86	109	81	133	130	113
Kuta Makmur	X7	84	83	46	143	54	42	0	132	63	82	65	51	59	63	35	39	98	87	47	65	97	32	50	45	99	99	67
Langkahan	X8	89	105	137	71	136	182	132	0	107	84	92	109	146	101	122	159	113	89	103	186	119	135	95	114	97	144	104
Lapang	X9	39	28	67	88	66	122	63	107	0	42	35	36	80	41	57	103	71	56	18	124	44	78	19	43	54	83	10
Lhoksukon	X10	27	40	85	73	84	116	82	84	42	0	40	50	96	51	72	109	75	51	58	136	61	88	49	55	45	93	49
Matag Kuli	X11	39	34	69	82	68	124	65	92	35	40	0	19	79	27	55	102	49	25	32	129	70	73	23	25	78	65	32
Meurah Mulia	X12	53	51	66	99	53	109	51	109	36	50	19	0	80	18	43	87	55	45	25	107	72	46	24	10	96	59	32
Muara Batu	X13	103	98	23	135	21	67	59	146	80	96	79	80	0	76	26	43	111	100	61	69	111	67	63	61	112	95	67
Nibong	X14	51	59	78	88	65	121	63	101	41	51	27	18	76	0	32	79	64	50	10	99	69	46	13	16	95	53	22
Nisam	X15	80	74	17	111	18	73	35	122	57	72	55	43	26	32	0	40	88	77	37	70	87	40	40	37	88	72	44
Nisam Antara	X16	117	111	48	148	55	24	39	159	103	109	102	87	43	79	40	0	125	124	85	31	135	70	77	72	124	119	81
Paya Bakong	X17	106	92	101	111	101	136	98	113	71	75	49	55	111	64	88	125	0	42	66	162	104	99	56	62	131	101	66
Pirak Timu	X18	52	47	90	86	89	124	87	89	56	51	25	45	100	50	77	124	42	0	54	144	92	45	44	51	90	85	52
Samudra	X19	68	46	64	91	50	106	47	103	18	58	32	25	61	10	37	85	66	54	0	104	67	65	15	28	94	74	11
sawang	X20	144	139	55	175	72	54	65	186	124	136	129	107	69	99	70	31	162	144	104	0	162	102	115	103	151	140	119
Seuneudon	X21	35	40	101	123	100	132	97	119	44	61	70	72	111	69	87	135	104	92	67	162	0	108	72	78	44	115	44
Simpang Kramat	X22	84	93	55	137	56	86	37	135	32	88	73	46	67	46	40	70	99	45	65	102	108	0	44	40	93	83	69
Syamtalira Aron	X23	39	46	66	83	53	109	50	95	19	49	23	24	63	13	40	77	56	44	15	115	72	44	0	26	71	66	15
Syamtalira Bayu	X24	95	64	48	103	48	81	45	114	43	55	25	10	61	16	37	72	62	51	28	103	78	40	26	0	103	58	36
Tanah Jambo Aye	X25	17	40	101	103	102	133	99	97	54	45	78	96	112	95	88	124	131	90	94	151	44	93	71	103	0	139	61
Tanah Luas	X26	132	96	98	133	84	130	99	144	83	93	65	59	95	53	72	119	101	85	74	140	115	83	66	58	139	0	79
Tanah Pasir	X27	47	42	70	92	57	113	67	104	10	49	32	32	67	22	44	81	66	52	11	119	44	69	15	35	61	79	0

Source: google Maps satellite Description:
Remarks:

X1	Baktiya	X10	Lhoksukon	X19	Samudra
X2	Baktiya Barat	X11	Matag Kuli	X20	Sawang
X3	Banda Baro	X12	Meurah Mulia	X21	Seuneudon
X4	Cot Girek	X13	Muara Batu	X22	Simpang Kramat
X5	Dewantara	X14	Nibong	X23	Syamtalira Aron
X6	Geureudong Pase	X15	Nisam	X24	Syamtalira Bayu
X7	Kuta Makmur	X16	Nisam Antara	X25	Tanah Jambo Aye
X8	Langkahan	X17	Paya Bakong	X26	Tanah Luas
X9	Lapang	X18	Pirak Timu	X27	Tanah Pasir

Based on the grouping of the covering set as the table 1 above it is assumed that the minimum travel time between subdistrict cities is 40 minutes, it can be grouped into a Covering set as the following table 3:

Table3: Grouping of Inter-Station Mileage less than 40 minutes.

Locatin	from to the city district
S1	X1, X2,X10,X21,X25
S2	X1,X2,X9,X10,X11,X23,X27
S3	X3,X5,X13,X15,X20
S4	X4,X8,X10,X17,X18
S5	X3,X5,X23,X15
S6	X6,X12,X22,X26
S7	X7,X15,X16,X22
S8	X4,X8,X25
S9	X2,X9,X23,X27
S10	X1,X2,X4,X10,X18
S11	X2,X11,X14,X18,X23,X24
S12	X6,X12,X17,X26
S13	X3,X5,X13,X15,X20
S14	X11,X14,X23,X24,X26,X27
S15	X3,X5,X7,X13,X15,X16
S16	X7,X15,X16,X20
S17	X4,X12,X17,X18,X26
S18	X4,X10,X11,X17,X18,X26
S19	X19,X23,X24,X27
S20	X3,X13,X16,X20
S21	X1,X21
S22	X6,X,X7,X22
S23	X2,X9,X11,X14,X19,X23,X27
S24	X11,X14,X19,X22,X24
S25	X1,X8,X25
S26	X6,X11,X12,X14,X17,X28
S27	X2,X9,X14,X19.X23,X25,X27

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The result of the time distance grouping based on the set covering problem (SCP) is then used as the basis of the model formulation.

1. Model Formulation :
   At this stage is done by model development approach Integer Programming method 0 - 1. The steps of model development are as follows:

a) Definition of decision variables

The decision variables in this study are as following table 4.:

Table 4:: Definitin of varibles

r	Location	Var	Location
X1	Baktiya	X15	Nisam
X2	Baktiya barat	X16	Nisam antara
X3	Banda baro	X17	Paya bakong
X4	Cot girek	X18	Pirak timu
X5	Dewantara	X19	Saamudra
X6	Geureudong pase	X20	Sawang
X7	Kuta makmur	X21	Seuneudon
X8	Langkahan	X22	Simpang kramat
X9	Lapang	X23	Syamtalira aron
X10	Lhoksukon	X24	Syamtalira bayu
X11	Matag kuli	X25	Tanah jambo aye
X12	Meurah mulia	X26	Tanah luas
X13	Muara batu	X27	Tanah pasir
X14	Nibong		

Where Xi will be worth 0 or 1, Xi = 0 if in town sub district to i is not built Firefighters station, other Xi = 1 if in city sub district to i built Firefighters station.

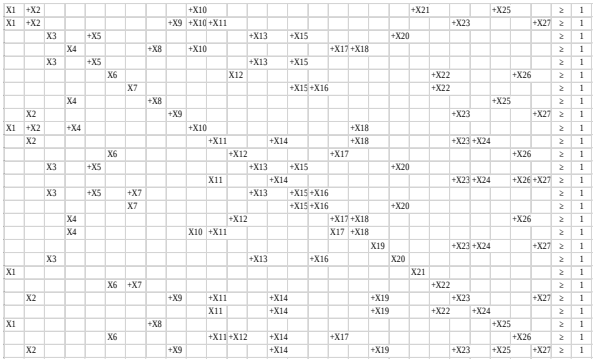
b) Establish the Objective f and Constraint fFnctions

The purpose of modeling in this study is to know the minimum number of Firefighters stations (Min Z) that must be built but able to reach all areas in less than 40 minutes. The method used for determining the location of the Firefighters station model is the Set Covering Problem (SCP) method. SCP method is the method used to determine the minimum number of facilities, and determine the location for each request can be fulfilled at least one facility quickly. This method is often used to overcome the problem of the number of facilities that must be available in an area to meet the demand.Based on the decision variables as the point above, the formulation of the model as follows:

Objective Function:

Min Z = X1+X2+X3+'X4+X5+X6+X7+ X8+X9 +X10 +X11+X12+X13+X14+X15+X16+X17+X18+ X19+X20+X21+X22+X23+X24+X25+X26+X 27

Subject To :



By: Xj = 0 or 1, for all j (j = 1, 2, 3 ...27)

c.) Implementation of Models
At this stage the search for solutions of the model has been developed, which was to determine the value of the decision variable values (Xi) and Minimum total number of Firefighters stations (the objective function). Solution would be done using the software model of software TORA windows® version 1.00, 2003 developed by Taha, Hamdy A. Input data models as presented in Figure 2 and output as models presented in Figure 3.

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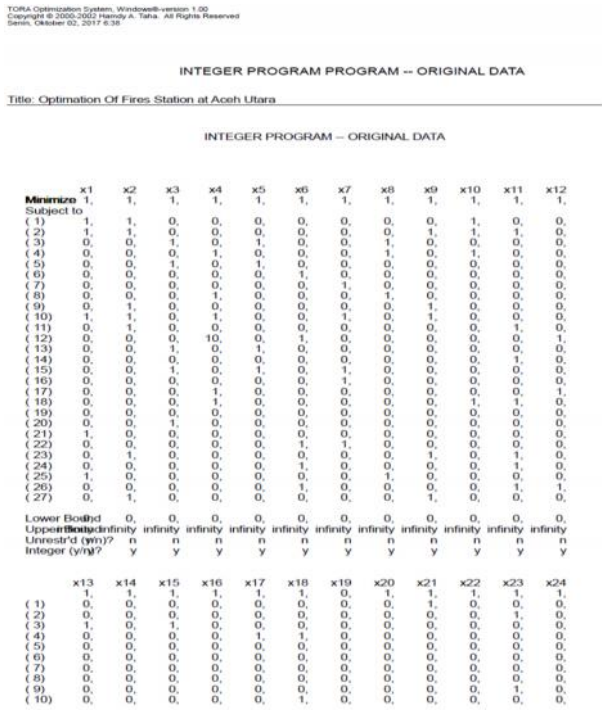


INTEGER PROGRAM PROGRAM -- ORIGINAL DATA

Title: Optimation Of Fires Station at Aceh Utara

INTEGER PROGRAM -- ORIGINAL DATA

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
Minimize	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,
Subject to												
(1)	1,	1,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,
(2)	1,	1,	0,	0,	0,	0,	0,	0,	1,	1,	1,	0,
(3)	0,	0,	1,	0,	1,	0,	0,	1,	0,	0,	0,	0,
(4)	0,	0,	0,	1,	0,	0,	0,	1,	0,	1,	0,	0,
(5)	0,	0,	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,
(6)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(7)	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,
(8)	0,	0,	0,	1,	0,	0,	0,	1,	0,	0,	0,	0,
(9)	0,	1,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,
(10)	1,	1,	0,	1,	0,	0,	1,	0,	1,	0,	0,	0,
(11)	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(12)	0,	0,	0,	10,	0,	1,	0,	0,	0,	0,	0,	1,
(13)	0,	0,	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,
(14)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(15)	0,	0,	1,	0,	1,	0,	1,	0,	0,	0,	0,	0,
(16)	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,
(17)	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,	0,	1,
(18)	0,	0,	0,	1,	0,	0,	0,	0,	0,	1,	1,	0,
(19)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(20)	0,	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(21)	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(22)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(23)	0,	1,	0,	0,	0,	0,	0,	0,	1,	0,	1,	0,
(24)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(25)	1,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,
(26)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	1,	1,
(27)	0,	1,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
Lower Bound	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n	n	n	n	n
Integer (y/n)?	y	y	y	y	y	y	y	y	y	y	y	y

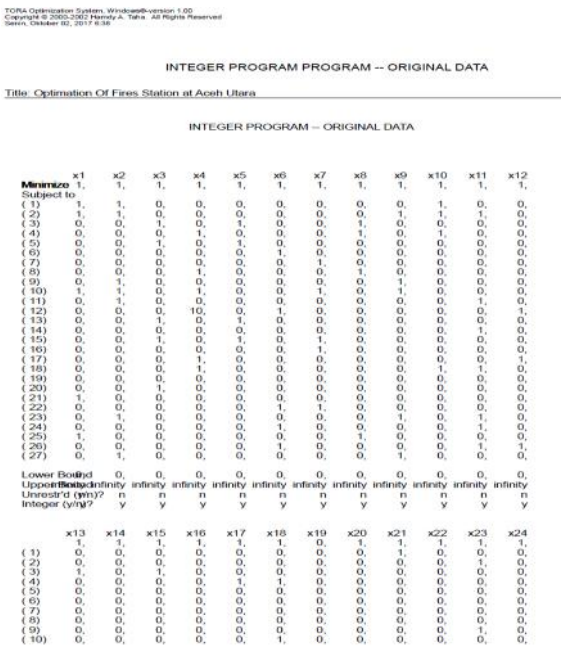
	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24
	1,	1,	1,	1,	1,	1,	0,	1,	1,	1,	1,	1,
(1)	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
(2)	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
(3)	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(4)	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,
(5)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(6)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(7)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(8)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(9)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(10)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,

Figure 3 : Input and Output Models using of TORA Ver 1.0

DISCUSSION

Based on the output model as shown in Figure 3 above, it is known that X1 = 1, X3 = 1, X4 = 1, X6 = 1, X7 = 1, X23 = 1, while for other Xj is zero, Based on these Results, it is interpreted that the Firefighters station in North Aceh District: Baktiya, Banda Baro, Cot Girek, Geureudong Pase, prosperous Kuta Makmur and Syamtalira. While this is done a new Firefighters station no 3 is located in District Alue Bili, Nisam, District Lhoksukon and Krung Mane. X3 = 1, X4 = 1, X6 = 1, X7 = 1, X23 = 1, while for the other Xj is zero, with a min objective function value of 6. Based on this result can be interpreted that station Firefighters station in North Aceh District must be built in 6 locations, namely sub-district: Baktiya, Banda Baro, Cot Girek,,Geureudong Pase, Kuta Makmur and Syamtalira Aron. While at the time of this study, there are 3 Firefighters stations located Alue Bili, Nisam district, Lhoksukon and Krung Mane sub districts, Muara Batu sub district.

CONCLUSION



INTEGER PROGRAM PROGRAM -- ORIGINAL DATA

Title: Optimation Of Fires Station at Aceh Utara

INTEGER PROGRAM -- ORIGINAL DATA

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
Minimize	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,	1,
Subject to												
(1)	1,	1,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,
(2)	1,	1,	0,	0,	0,	0,	0,	0,	1,	1,	1,	0,
(3)	0,	0,	1,	0,	1,	0,	0,	1,	0,	0,	0,	0,
(4)	0,	0,	0,	1,	0,	0,	0,	1,	0,	1,	0,	0,
(5)	0,	0,	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,
(6)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(7)	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,
(8)	0,	0,	0,	1,	0,	0,	0,	1,	0,	0,	0,	0,
(9)	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(10)	1,	1,	0,	1,	0,	0,	1,	0,	1,	0,	0,	0,
(11)	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(12)	0,	0,	0,	10,	0,	1,	0,	0,	0,	0,	0,	1,
(13)	0,	0,	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,
(14)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(15)	0,	0,	1,	0,	1,	0,	1,	0,	0,	0,	0,	0,
(16)	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,
(17)	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,	0,	1,
(18)	0,	0,	0,	1,	0,	0,	0,	0,	0,	1,	1,	0,
(19)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(20)	0,	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(21)	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(22)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(23)	0,	1,	0,	0,	0,	0,	0,	0,	1,	0,	1,	0,
(24)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,
(25)	1,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,
(26)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	1,	1,
(27)	0,	1,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
Lower Bound	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
Upper Bound	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity	infinity
Unrestr'd (y/n)?	n	n	n	n	n	n	n	n	n	n	n	n
Integer (y/n)?	y	y	y	y	y	y	y	y	y	y	y	y

	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24
	1,	1,	1,	1,	1,	1,	0,	1,	1,	1,	1,	1,
(1)	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
(2)	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,	0,	0,
(3)	1,	0,	1,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(4)	0,	0,	0,	0,	1,	1,	0,	0,	0,	0,	0,	0,
(5)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(6)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(7)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(8)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,
(9)	0,	0,	0,	0,	0,	0,	0,	0,	0,	0,	1,	0,
(10)	0,	0,	0,	0,	0,	1,	0,	0,	0,	0,	0,	0,

INTEGER PROGRAMMING B&B OUTPUT SUMMARY

Title: Optimation Of Fires Station at Aceh Utara

OPTIMAL SOLUTION
Objective Value = 6 (MIN)
Optimum solution found at iteration 1
Result verified at iteration 2

x1 = 1
x2 = 0
x3 = 1
x4 = 1
x5 = 0
x6 = 1
x7 = 1
x8 = 0
x9 = 0
x10 = 0
x11 = 0
x12 = 0
x13 = 0
x14 = 0
x15 = 0
x16 = 0
x17 = 0
x18 = 0
x19 = 0
x20 = 0
x21 = 0
x22 = 0
x23 = 1
x24 = 0
x25 = 0
x26 = 0
x27 = 0

Figure 3 : Input and Output Models using of TORA Ver 1.0 (continued)

From the results of the above study can be concluded as follows:

1. The number of optimal Firefighters stations to be built in the area of North Aceh District is 6 stations, so it is necessary to add 3 more Firefighters stations.
2. Firefighters station locations are:
   - In Baktiya Subdistrict
   - In Banda Baro Subdistrict
   - In Cot Girek Subdistrict
   - In Geureudong Pase Subdistrict
   - In Kuta Makmur Subdistrict
   - In Syamtalira Arun Subdistrict
3. Relocation of existing Firefighters station is required to the locations as point 2 above.

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ACKNOWLEDGMENTS

Based on the conclusions, as mentioned above, it is hereby recommended to the Government of North Aceh as follows:1. to review the current compression of Firefighters stations and relocate in accordance with the results of this study.2. Adding an existing Firefighters Station from 3 to 6 stations.3. Need to do further research by considering the cost factor, both investment cost, operational cost and cost-benefit ratio (Benefit Cash Ration).

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