International Journal of Economics, Business Management and Accounting (IJEBMA)
Vol.4, No.2, 2022: 75-84

Optimization of Recreational Park Development in Klaten District by Using Critical Path Method (CPM)

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A R T I C L E I N F O

Keywords: Critical Path Method, Manajemen Proyek, Optimasi, Crassing

Received : 3 June
Revised : 18 June
Accepted : 20 July

A B S T R A C T

Recreation Parks are one of the tourist/visit destinations for people to fill their free time or vacation. The plan to build a recreation park in Klaten Regency is expected to be completed within 70 days. By preparing good project management, it is possible to estimate the time and costs required to carry out the project, so that the project can be completed within the desired time with minimum total costs. The method used to solve this problem is the optimization of the critical path method. The critical path method is a method used to determine the sequence of critical activities or activities that cannot be postponed along with the fastest total time to complete the entire project. The results of the discussion using the Critical Path Method regarding the problem of building a Recreational Park project in Klaten Regency showed that the fastest time to complete the project was 84 days at a cost of Rp. 540,000,000,- and after optimization according to the expected time (70 days), the costs that must be incurred are Rp. 566,750,000

INTRODUCTION

Project management is the planning, implementation, control and coordination of a project from the beginning (idea) to the end of the project to ensure project implementation on time, on cost and on quality [10]. What must be done in optimizing time and costs is to create a project network, look for critical activities and calculate the project duration [3]. One method that is often used to determine the critical path is the Critical Path Method (CPM).

CPM or Critical Path Method, in Indonesian means Critical Path Method, is a management science model for planning and controlling the costs of a project [9].

The critical path aims to identify activities that have a high level of sensitivity to implementation delays, so that it can determine the level of policy priority in project implementation. This form of CPM can provide information related to activities carried out first or afterwards, and the duration of the activity [1].

The critical path method optimization algorithm [6] is as follows:

1. Find the critical path for normal costs.
   (for example tij is the time needed to complete the activity from point i to point j).
   - Calculate the fastest time to start the activity at point-j (Earliest Start/ES)
   $$ES_j = \max_i ES_i + t_{ij}$$
   - Calculate the latest time to start the activity at point-i (Latest Completion/LC)
   $$LC_i = \min_j LC_j - t_{ij}$$
   - The critical path is obtained from the path where ES=LC
2. Determine the slope of each job on the critical path.
   $$\text{Slope} = \frac{\text{Biaya Crash} - \text{Biaya Normal}}{\text{Waktu Normal} - \text{Waktu Crash}}$$
3. Determine the smallest slope (eg: mk).
4. Reduce the completion time of k-activities as small as possible without changing the critical path.
5. Repeat steps 3-4 until no more activities can be accelerated without changing the critical path.
6. Speed up processing time for each activity with the next smallest slope, but taking into account the effect on non-critical paths

LITERATURE REVIEW

Research on the application of the critical path method has been discussed previously by Perdana [4] with the title "Application of Project Management using the CPM (Critical Path Method) Method in SPBE Development Projects" in the community service journal. Furthermore, by Lokajaya [3] in the Industrial Engineering journal with the title "Analysis of Time and Cost Control in Road Improvement Projects using the CPM and PERT Methods" with the results of total cost research based on optimal time from 275 days amounting to Rp. 24,972,450,794.11 to 252 days amounting to IDR 24,972,998,294.11. Other relevant research can be seen in [2], [5], and [7]. Meanwhile, this research will analyze the

optimal time and costs in the Recreational Park Development project in Klaten Regency using the Critical Path Method (CPM)

METHODOLOGY

A. Type of Research

This research is research with a quantitative approach. This research is applied research which aims to provide practical solutions to certain problems in everyday life [8].

B. Data Source

The type of data in this research is primary data, namely data collected by the researcher directly from the research object in the form of a sequence of production processes and the time required to carry out each activity. And the data source was obtained from the Recreation Park Project Manager in Klaten Regency. Where each activity is influenced by time and costs.

C. Data Analysis Techniques

The data analysis steps used in this research are:

1. Create a project network using normal time.
2. Determine the critical path of the project network.
3. Optimize costs on the critical path.

a. Determine the slope of each activity on the critical path.
b. Determine the smallest slope (eg mk).
c. Reducing the completion time of k-activities as small as possible without changing the critical path.
d. Repeat steps b-c until no more activities can be accelerated without changing the critical path
e. Speed up processing time for each activity with the next smallest slope, but taking into account the effect on non-critical paths.

4. Determine activities that are still possible to postpone

RESULT AND DISCUSSION

The data used in this research is data originating from the project manager for the construction of a Recreational Park in Klaten Regency. This construction is expected to be completed in 70 working days. The Recreation Park construction project in Klaten Regency consists of 14 activities which can be seen from the following table.

Table 1. Recreation Park Project Activity Data

No.	Activity	Code Activity	Previous Activity	Working (days)	Time
1.	Location Survey	A	-	6	
2.	Desain	B	A	6	
3.	Purchase of tools and materials	C	B	3	
4.	Leveling the ground	D	B	4	
5.	Pool	E	C	10	

6.	Mosque dan toilet	F	C, D	35
7.	Gazebo	G	C, D	14
8.	Street	H	E, F, G	15
9.	Parking area	I	E, F	7
10.	Electricity and lights	J	E, F	3
11.	Fence	K	H, I	12
12.	Plant trees and flowers	L	H, I	3
13.	Place play equipment	M	J, K	1
14.	Painting	N	L, M	5

Table 2. Crash Time and Cost Data

Activity	**Time**		**Cost**	
	Normal	Crash	Normal	Crash
A	6	3	5000	11000
B	6	4	20000	23500
C	3	1	125000	150000
D	4	3	12000	15500
E	10	7	25000	28300
F	35	28	145000	180000
G	14	10	65000	80000
H	15	12	78000	87000
I	7	5	15000	18000
J	3	1	7000	10000
K	12	7	18000	25000
L	3	2	10000	14000
M	1	1	3000	3000
N	5	4	12000	15000

Create a Project Network Using Normal Time

From Table 1, it can be seen that the predecessor activity is activity A (site survey) and the final activity is activity N (painting), so that the activities in this project can be made into a network model as shown in the following figure.

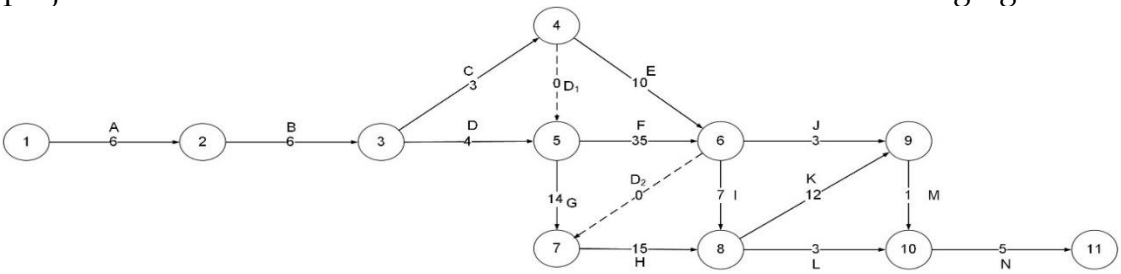

Figure 1. Recreation Park Project Network Model

There are 2 additional dummy activities in the project network. Dummy activity D1 was added because activities C and D were prerequisites for activities F and G. Dummy activity D2 was added because activities E, F, and G were prerequisites for activity H.

Determine the Critical Path of the Project Network

The critical path of the project network is obtained from the path from the start point to the end point that passes through all points with ES=LC.
By using the formula:

$$ES_j = \max_i ES_i + t_{ij}$$
$$LC_i = \min_j LC_j - t_{ij}$$

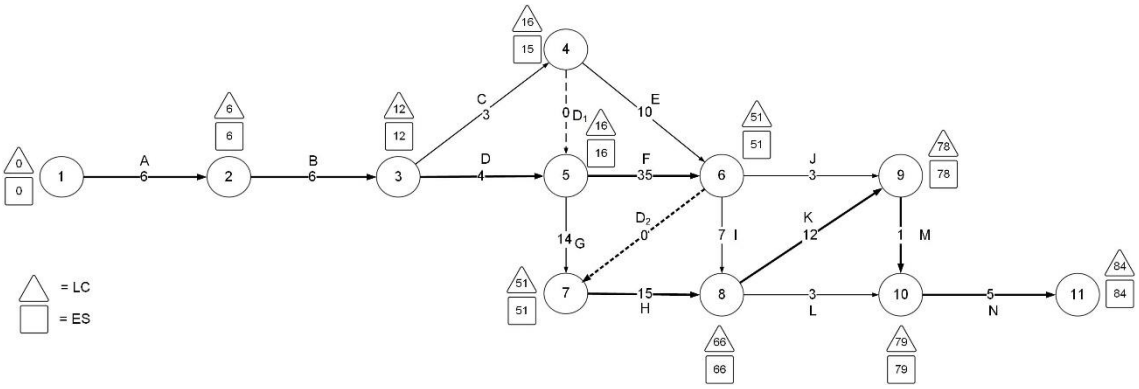

Figure 2. Critical Path of the Recreation Park Project Network

From Figure 2, it can be seen that the critical path of the recreational park project network is A-B-D-F-D2-H-K-M-N.
From the critical path, the fastest time required to complete the recreation park project can be calculated, namely 6+6+4+35+0+15+12+1+5 = 84 days

Optimize Costs on the Critical Path

From the critical path calculation, the recreation park project can be completed within 84 days with the costs incurred being 5000 + 20000 + 125000 + 12000 + 25000 + 145000 + 65000 + 78000 + 15000 + 7000 + 18000 + 10000 + 3000 + 12000 = IDR 540,000 thousand.

The construction of the Recreation Park project is expected to be completed within 70 working days. So work on the Recreation Park project needs to be accelerated by 14 days. To speed up the work requires additional costs. The first recreation park project cost optimization was carried out by determining the slope which expressed the amount of increase in costs for a decrease in one unit of work time.

Table 3. Slope Value for Each Activity

Activity	Time		Cost		A	B	C
	Normal	Crash	Normal	Crash			
A	6	3	5000	11000	3	6000	2000
B	6	4	20000	23500	2	3500	1750
C	3	1	125000	150000	2	25000	12500
D	4	3	12000	15500	1	3500	3500
E	10	7	25000	28300	3	3300	1100
F	35	28	145000	180000	7	35000	5000
G	14	10	65000	80000	4	15000	3750
H	15	12	78000	87000	3	9000	3000
I	7	5	15000	18000	2	3000	1500
J	3	1	7000	10000	2	3000	1500
K	12	7	18000	25000	5	7000	1400
L	3	2	10000	14000	1	4000	4000
M	1	1	3000	3000	0	0	-
N	5	4	12000	15000	1	3000	3000

Information :
A = Decreased time (normal time – crash time)
B = Additional costs (crash costs – normal costs)
C = Slope (B/A)
Reduce or reduce project completion time by pressing as many activities as possible on the critical path that has the smallest slope.
- From Table 3. The activity on the critical path with the smallest slope is activity K (making fences). Thus, K activity can be suppressed for 5 days (12 → 7). The following are changes to the project completion time.

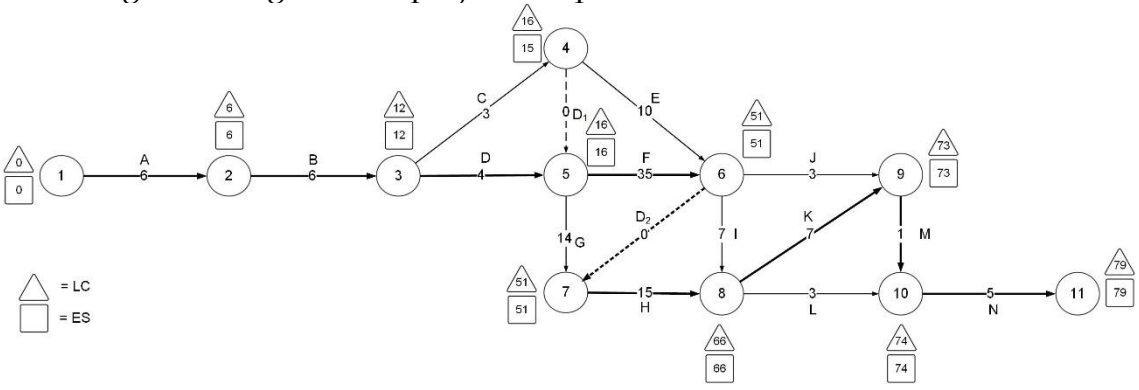

Figure 3. Recreation Park Project Network With Decreased Time on Activity K

So the completion time for the recreation park project is 79 days with a cost of 540,000 + 5. 1400 = Rp. 547,000 (thousand)

- Because the project completion time is not yet as expected (70 days), it is necessary to reduce other critical activities which have the smallest slope after activity K, namely activity B (design) by 2 days (6 → 4). The following are changes to the project completion time.

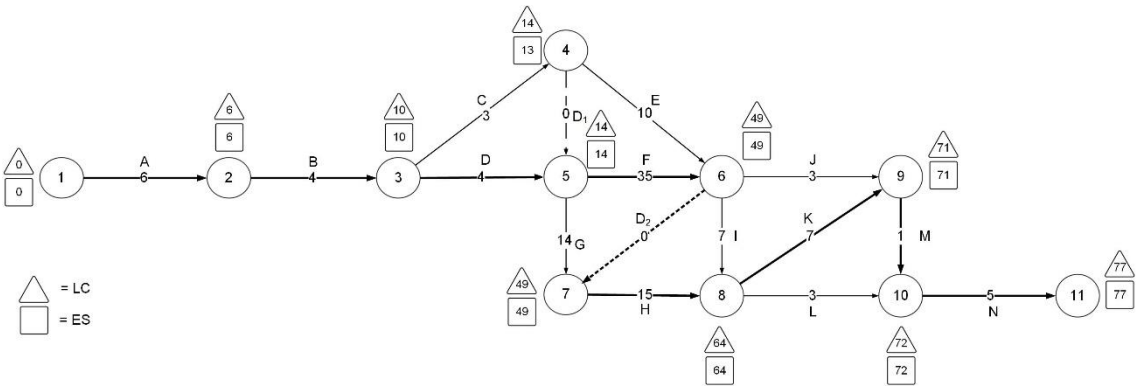

Figure 4. Recreational Park Project Network with Decreased Time for Activities K and B

So the completion time for the recreation park project is 77 days with a cost of 547,000 + 2 . 1750 = Rp. 548,750 (thousand)

- Because the project completion time is not yet as expected (70 days), it is necessary to reduce other critical activities which have the smallest slope after activities K and B, namely activity A (site survey) by 3 days (6 → 3). The following are changes to the project completion time.

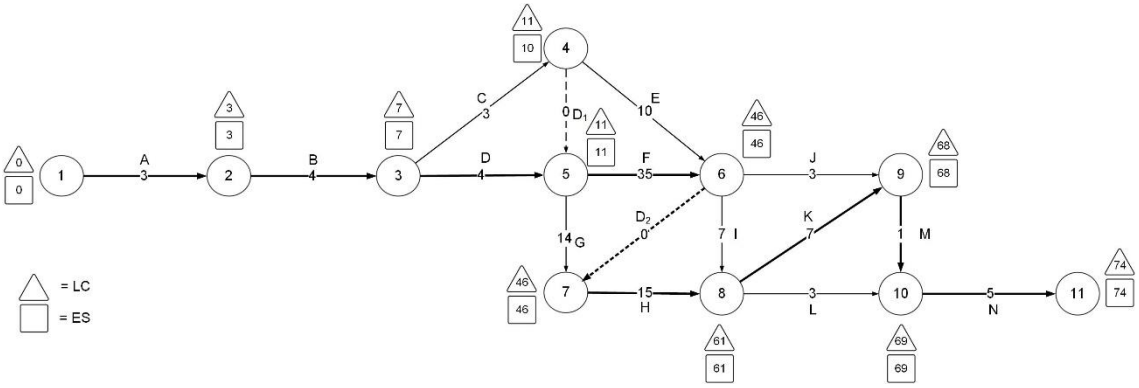

Figure 5. Recreational Park Project Network With Decreased Time For Activities K, B, and A

So the completion time for the recreation park project is 74 days with a cost of 548,750 + 3. 2000 = Rp. 554,750 (thousand)

- Because the project completion time is not yet as expected (70 days), it is necessary to suppress other critical activities which have the smallest slope after activities K, B and A, namely activities H and N with a slope of 3000. Activity H is reduced or suppressed by 3 days (15 → 12) and N activity for 1 day (5 → 4). The following are changes to the project completion time.

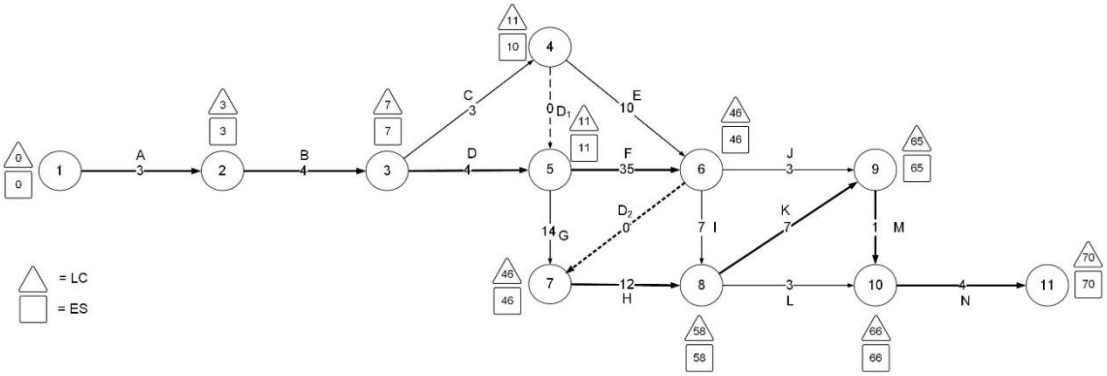

Figure 6. Recreational Park Project Network With Decreased Time for Activities K, B, A, H, and N

So the completion time for the recreational park project is 70 days with a cost of 554,750 + 4. 3000 = Rp. 566,750 (thousand).

Determine Activities that are Still Possible to Postpone

Total Slack (TS) is the total free time available to carry out activities.

$$TS_{ij} = LC_j - ES_i - t_{ij}$$

Free Slack (FS) is free time that is still available if all activities are started as quickly as possible.$FS_{ij} = ES_j - ES_i - t_{ij}$

Table 4. Total Slack and Free Slack Values

Aktivitas	ESi	ESj	LCi	LCj	tij	TSij	FSij
1 → 2	0	3	0	3	3	0	0
2 → 3	3	7	3	7	4	0	0
3 → 4	7	10	7	11	3	1	0
3 → 5	7	11	7	11	4	0	0
4 → 5	10	11	11	11	0	1	1
4 → 6	10	46	11	46	10	26	26
5 → 6	11	46	11	46	35	0	0
5 → 7	11	46	11	46	14	21	21
6 → 7	46	46	46	46	0	0	0
6 → 8	46	58	46	58	7	5	5
6 → 9	46	65	46	65	3	16	16
7 → 8	46	58	46	58	12	0	0
8 → 9	58	65	58	65	7	0	0
8 → 10	58	66	58	66	3	5	5
9 → 10	65	66	65	66	1	0	0
10 → 11	66	70	66	70	4	0	0

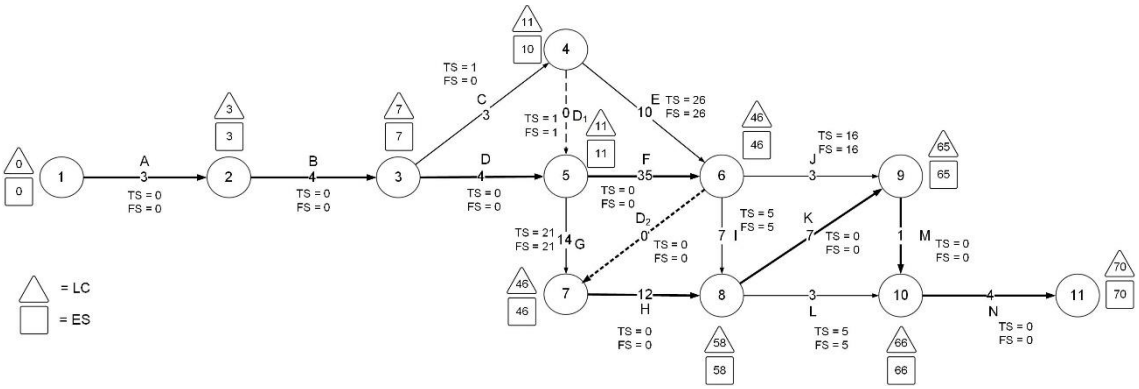

Figure 7. Optimal Network for Recreational Park Projects With Total Slack and Free Slack

CONCLUSION AND RECOMMENDATION

The application of the critical path method in optimizing the construction of recreational parks in Klaten Regency is useful in determining the time and costs required. Using the critical path method, the time required to build the project is 84 days with costs of IDR 540,000,000. After optimizing the critical path method with a project target of completion in 70 days, the costs that must be incurred are IDR 566,750,000. And activities that cannot be late or must be completed on time are site surveys, design, leveling the land, making prayer rooms and toilets, roads, fences, laying out play equipment and painting.

FURTHER STUDY

This research still has limitations, so it is necessary to carry out further research related to the topic of Optimization Of Recreational Park Development In Klaten District By Using Critical Path Method (Cpm)to improve this research and add insight to readers.

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