QUANTITATIVE METHOD FOR OPTIMIZING DECISION IN PROJECT SELECTION

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ABSTRACT: The Indonesian economic and monetary condition recently has made changeover in many development policies including built environment. For example is the policy on selecting the built environmental project to be developed in the context of sustainable both environment and business. This research's report presents an approach to apply quantitative methods for optimizing decision in built environment project selection. The approach based on decision hierarchy that was obtained from 32 respondents in a survey study. It was completed with an implementation by a case study that is one of the biggest private construction projects in Indonesia to evaluate the application of that method. Model formulated and its implementation based on application of Analytic Hierarchy Process (AHP) method for multi criteria decision and Goal Programming (GP) method for multi objective decision and its optimization in a project selection. The result presents that complete design and permission; available funds; construction cost and probability to capital return are the most significant factors in decision. The implementation result demonstrates a process to select priorities each project to each decision and the optimization concludes that public park project, landfill sanitation project and supermarket project are selected and to be continued, but swimming pool is delayed and hospital is terminated. Follow up research is particularly required, primarily a study of decision support system and expert systems.

Keywords: Quantitative method, optimizing decision, project selection

1. INTRODUCTION

Indonesian property and construction industry have business cycles in a short period. Change management for project selection always relevant in a corporate planning. It means that not only on an economic crisis period but also as long as their business cycles, a developer and a contractor company will be faced the decision to terminate, to postpone or to continue their construction project. Decision for unfinished construction project is very complicated since many parties involves in a critical time. Where a number of stakeholders are involved in choosing a single alternative from a set of solution alternatives, there are different concern caused by differing stakeholder preferences, experiences, background. The decision is a part of the strategic project management and project controlling. Decision for unfinished construction project is a decision problem that can be solved by quantitative method. (Markland, 1987 ; Meredith, 1995 ; Badiru, 1995 ; Hesse, 1997 and Render, 2000). Researches on project selection or termination field mostly are grouped on project controlling (Shtub, 1994; Cleland, 1996 and Oberlender, 2000) but only little have an approach to the project postponed. The approach usually starts with a project performance evaluation (Chua, 1999).

The objective of this research is to develop a model for decision support and optimization by applying operation research method. It is described as a decision that used mathematic modeling and computer aid to solve a managerial problem in a rational decision (Mathur, 1994). Two studies were conducted that are a survey and a case study to apply the method in a real condition.

2. DECISION MODEL AND SUPPORT SYSTEM

2.1 Decision Model

The analytical hierarchy process (AHP) is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and its quantitative aspects of a decision need to be considered (Saaty, 1996). The same opinions indicate that AHP is appropriate for the task of selecting components when several criteria must be considered (Cangussu, et al., 2006). AHP provides the framework to view the problems in an organized but complex framework that allows for interaction and interdependence among factors and still enables the decision maker to think about them in a simple way (Pandejpong, 2002). The general concept of AHP is about decomposing a problem into sub problems and then aggregating the solutions of all the sub problems into a conclusion (Chantrasa, 2005).

Researchers used AHP in various industrial applications. Ghasemzadeh (1999) presented a model for project portfolio selection and scheduling using zero-one, a one kind of Multi Criteria Decision Making (MCDM) method. Mian and Christine (1999) used AHP for evaluation and selection of a private sector project. Bhattacharya and Dey (2003) applied AHP in power sector for selecting power market structure. They argued that selection of power market structure depends on various factors like technical, socio-economic, and financial. In this research, compilation of hierarchical problems is obtained through analysis and testing of survey concerning decision-maker opinion (project managers). Opinions are given in Dickson scale (Yahya and Kingsman, 1999) that are 1(very insignificant), 2(not important), 3(moderate), 4(important) and 5(very important). Table 1 presents list of significant factor in project selection and termination of unfinished construction project based on calculation of mean and standard deviation.

Table 1. Significant Factors of Unfinished Construction Project Decision

			SIGNIFICANT FACTORS	Mean	Std.dev.
GROUP OF SIGNIFICANT FACTORS	I	1	Complete design and legal aspect	4.30	0.65695
		2	Available funds for operation and maintenance	4.30	0.73269
		3	Probability to capital return (rate of return)	4.30	0.92338
	II	4	Effect of delay to market housing	4.25	0.71635
		5	Effects to cash flow decision	4.25	0.91047
	III	6	Benefit of the project facilities to project value	4.20	0.69585
		7	Financial benefits	4.20	0.83351
		8	Construction cost	4.15	0.74516
		9	Potential market of project facilities	4.10	0.85224
	IV	10	Construction cost variations	4.05	0.75916
		11	Financial risk of facilities development	4.05	0.75916
		12	Uncertainty of market demand	4.05	0.82558
	V	13	Possibility of project will be finished	4.00	0.64889
		14	Consumer image	4.00	0.64889
	VI	17	Consumer acceptance	3.95	0.75916
		18	Investment ratio between facilities and housing	3.95	0.88704
	VII	19	Relevant to a long term business objectives	3.90	0.78807
		20	In compliance with housing market	3.90	0.78807
		21	Technical impact of termination	3.85	0.74516
	VIII	22	Contractors arrangement	3.80	0.76777
		23	Adaptation to focus of business	3.80	1.00525

2.2 Constructing Decision Hierarchy

To obtain a good representation of a problem, it has to be structured into different components called activities. Figure 1 shows that the goal of the problem (G ="to select best decision for unfinished constructed project") is addressed by some alternatives (A = A1; A2; A3; A4; A5). The problem is split into sub-problems (C1; C2; C3; C4; C5; C6; C7) which are criteria evaluating alternatives. These criteria (C) are split in sub-criteria. Decision hierarchy model might possibly be modified by considering factors dominance cluster by this consideration more accurately with flexibility at adjustment of condition of corporation. Then implementation of analytical hierarchy can be started with compilation of hierarchy model. Adjustment especially at choice to sub criteria, but it remains to be strived to give implementation as complete possibly. Table 2 shows a process of decision. The result is presented in Table 3.

2.3 Making Judgment

The relative importance of pairwise comparison could be: equal (1), moderate (3), strong (5), very strong, demonstrated (7) or extreme (9). Sometimes one needs compromise judgments (2; 4; 6; 8) or reciprocal values (1/9; 1/8; 1/7; 1/6; 1/5; 1/4; 1/3; 1/2). For pairwise comparisons between n similar activities with respect to the criterium ck, a matrix Ack = (aij)i;j_*n* is a preferred form. Synthesis of AHP is presented in Table 2, Figure 2, Figure 3, and Figure 4.

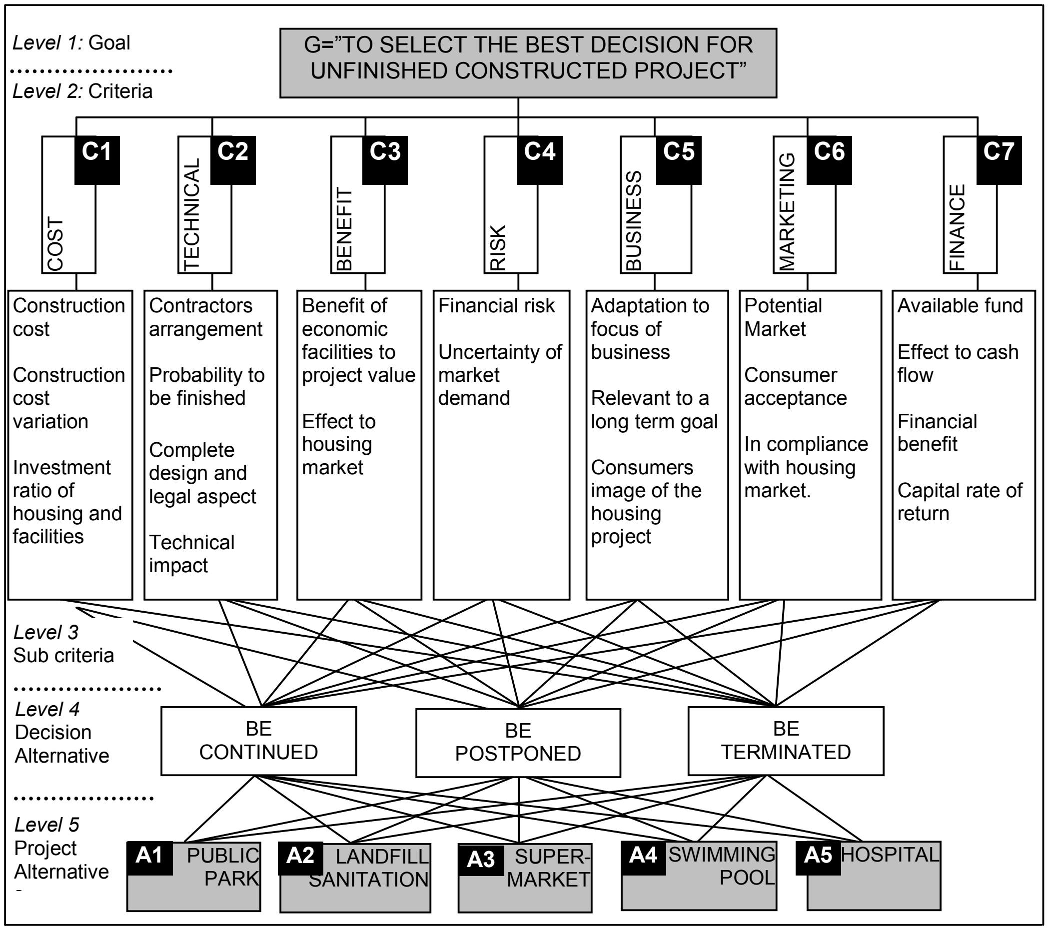

Figure 1. Decision hierarchy for project selection

Table 2. Synthesis of Analytic Hierarchy Process

	Weighting factor of criteria (Consistency ratio is 0.010269)							WEIGTH OF ALTERNATIVE
	C1 0.0433	*C2* 0.0291	*C3* 0.0718	*C4* 0.1204	*C5* 0.2029	*C6* 0.1927	*C7* 0.3399	
BE POSTPONED								
A1	0.2604	0.1771	0.0521	0.0391	0.2589	0.0972	0.0821	0.124019
A2	0.4484	0.0947	0.2747	0.1444	0.0944	0.1171	0.1712	0.159177
A3	0.1619	0.0459	0.1506	0.1987	0.0946	0.0887	0.1089	0.116363
A4	0.0797	0.2229	0.0839	0.1085	0.1746	0.1993	0.1927	0.168355
A5	0.0496	0.4594	0.4388	0.5093	0.3775	0.4979	0.4452	0.432187
BE CONTINUED								
A1	0.1404	0.1243	0.5049	0.2856	0.2313	0.2365	0.4426	0.323263
A2	0.0759	0.2422	0.2586	0.1182	0.3319	0.2935	0.2791	0.261908
A3	0.4583	0.5016	0.1274	0.2273	0.1854	0.3069	0.0999	0.201665
A4	0.2529	0.0714	0.0546	0.3212	0.1566	0.1131	0.1334	0.154511
A5	0.0726	0.0606	0.0546	0.0477	0.0949	0.0501	0.0449	0.058753
BE TERMINATED								
A1	0.0916	0.1763	0.0435	0.0678	0.1585	0.0901	0.0636	0.091526
A2	0.5644	0.0678	0.0841	0.2351	0.1068	0.0733	0.0779	0.123029
A3	0.2323	0.0349	0.1674	0.1144	0.1593	0.1252	0.2037	0.162531
A4	0.0571	0.2183	0.2861	0.0799	0.1408	0.2061	0.1977	0.174492
A5	0.0546	0.5028	0.4189	0.5029	0.4347	0.5052	0.4571	0.448523

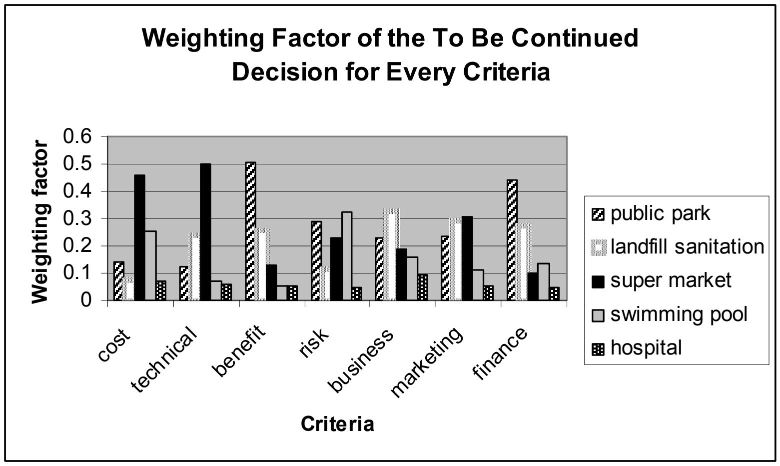

Figure 2. Weighting Factor of Every Alternatives to Every Decision

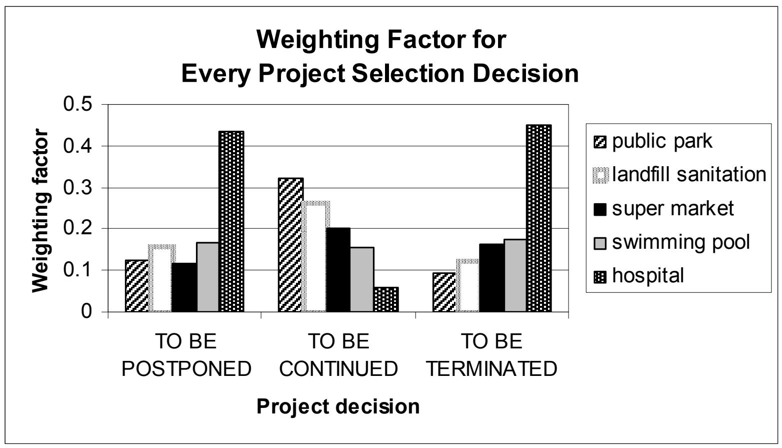

Figure 3. Weighting Factor of Every Alternatives to Every Decision

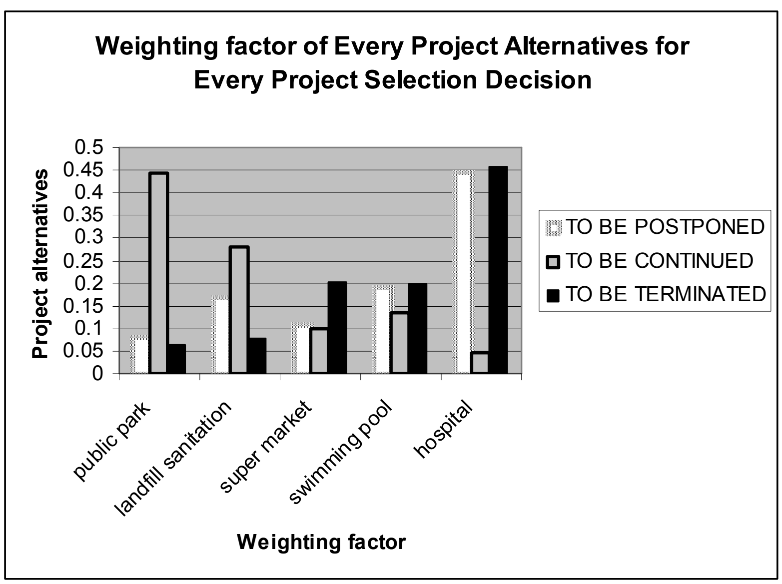

Figure 4. Weighting Factor of Every Alternatives to Every Decision

Table 3. Decision Alternatives

Priorities	Decision Alternatives		
	POSTPONED	CONTINUED	TERMINATED
1	Hospital	Public park	Hospital
2	Swimming pool	Landfill sanitation	Swimming pool
3	Landfill sanitation	Swimming pool	Supermarket
4	Public park	Supermarket	Landfill sanitation
5	Supermarket	Hospital	Public park

2.4 Judgment Synthesis

If *n* is the size of the pairwise comparison matrix Ack = (aij)i;j_*n*, the eigenvector which is associated represents the priorities of the activities with respect to ck (Wck = (wi)i_n). The AHP measures the overall consistency of judgments by means a consistency ratio: CRAck = CIAck =RCn. The higher consistency ratio is, the less consistent preferences are. The value of the consistency ratio should be 10% or less. Under this condition the priorities can be calculated.

3. DECISION OPTIMIZATION

By project decomposition and decision alternatives, optimization variables can be set as the result as follow: X1, 1 (public park will be continued); X1, 2 (public park will be postponed); X1, 3 (public park will be terminated); X2, 1 (Landfill sanitation will be continued); X2, 2 (Landfill sanitation will be postponed); X2, 3 (Landfill sanitation will be terminated); X3, 1 (supermarket will be continued); X3, 2 (supermarket will be postponed); X3, 3 (supermarket will be terminated); X4, 1 (swimming pool will be continued); X4, 2 (swimming pool will be postponed); X4,3 (swimming pool will be terminated); X5,1 (hospital will be continued); X5,2 (hospital will be postponed); X5,3 (hospital will be terminated). Constraint of goal objective function is decision cost of each project. Function of cost (Million USD) as follow;

$X1,1 + d1^- - d1^+ = 10.4$ (construction of public park's project is continued)

$X1,2 + d2^- - d2^+ = 5.24$ (construction of public park's project is postponed)

$X1,3 + d3^- - d3^+ = 1.8$ (construction of public park's project is terminated)

$X2,1 + d4^- - d4^+ = 10.5$ (construction of landfill's project is continued)

$X2,2 + d5^- - d5^+ = 4.37$ (construction of landfill's project is postponed)

$X2,3 + d6^- - d6^+ = 6$ (construction of landfill's project is terminated)

$X3,1 + d7^- - d7^+ = 3.5$ (construction of supermarket's project is continued)

$X3,2 + d8^- - d8^+ = 7$ (construction of supermarket's project is postponed)

$X3,3 + d9^- - d9^+ = 2.5$ (construction of supermarket's project is terminated)

$X4,1 + d10^- - d10^+ = 6.25$ (construction of swimming pool's project is continued)

$X4,2 + d11^- - d11^+ = 3.90$ (construction of swimming pool's project is postponed)

$X4,3 + d12^- - d12^+ = 1.5$ (construction of swimming pool's project is terminated)

$X5,1 + d13^- - d13^+ = 23.75$(construction of hospital's project is continued)

$X5,2 + d14^- - d14^+ = 12.5$ (construction of hospital's project is postponed)

$X5,3 + d15^- - d15^+ = 1.25$ (construction of hospital's project is terminated)

Where $di^-, di^+ \geq 0$ for all of I

Function of cost for all project alternatives is,

$$X1,1 + X2,1 + X3,1 + X4,1 + X5,1 + X1,2 + X2,2 + X3,2 + X4,2 + X5,2 + X1,3 + X2,3 + X3,3 + X4,3 + X5,3 + d16^- - d16^+ = 32.25 \text{ Million USD.}$$

Objectives function with preemptive priority, P1= Total cost function and P2 = function of goal constraint every project is:

$$\text{Minimize } P1 (d16^+) + P2 (A1d1^- + A2d2^- + A3d3^- + B1d4^- + B2d5^- + B3d6^- + C1d7^- + C2d8^- + C3d9^- + D1d10^- + D2d11^- + D3d12^- + E1d13^- + E2d14^- + E3d15^-)$$

By entering preference synthesis of project to alternative of decision (Table 2) the goal objective function can be formulated as follows:

$$\text{Minimize } P1 (d16^+) + P2 (0.323263d1^- + 0.124019d2^- + 0.091526d3^- + 0.261908d4^- + 0.159177d5^- + 0.123029d6^- + 0.201665d7^- + 0.116363d8^- + 0.162531d9^- + 0.154511d10^- + 0.168355d11^- + 0.174492d12^- + 0.058753d13^- + 0.432187d14^- + 0.448523d15^-)$$

Solution of the optimization was concluded for each project: (1) public park project is decided to continue; (2) landfill sanitation project is decided to continue, (3) supermarket is selected and decided to continue; (4) Swimming pool is decided to postpone; and (5) hospital is decided to terminate. Total costs are 29.55 Million USD. The decision and solution based on cost constraint. The constraint was limited to project total cost that is 32.25 Million USD.

4. CONCLUSION

a) Complete design and permission, available funds, construction cost and probability to capital return are the most significant factors in decision of unfinished construction project.

b) The implementation results demonstrates a process to select priorities each project to each decision and the optimization by Goal Programming conclude that public park project, landfill sanitation project and supermarket project are selected and to be continued, but swimming pool is delayed and hospital is terminated

c) Quantitative method and computer application becomes a practical approach in decision support. Follow up research is particularly required, primarily a study of decision support system and expert systems.

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