CONSIDERING THE INTEGRATED VALUE ENGINEERING AND RISK MANAGEMENT TECHNIQUES DURING THE DESIGN PHASE IN CONSTRUCTION PROJECTS – ITS IMPLICATIONS TO PROJECT OBJECTIVES

(A Case Study on Certain Irrigation Projects, North Sulawesi Province)

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ABSTRACT

In encouraging of the success of irrigation projects, the implementation of value engineering technique as well as managing risks as recognized and as important in management process has been placed into consideration, and put those two concurrently into a single integrated process. The integrated approach is considered to assist a clear link to achieve the project's objectives in terms of, in this case, time, cost, and quality. The purpose of this study is to identify and analyze factors in conjunction with risks and value and in association with optimal approach on the development of construction projects via design solutions during the design and engineering phase in accordance to the project's objectives, based on data from questionnaires, interviews, and projects' documentations, mostly from the respondents' responses. Those factors are ranked in term of their effects to project time, cost, and quality. Four factors that are related to project time, five factors linked to project cost, and two factors associated with project quality. Other result is factors that affecting simultaneously, as an overall to the project objectives, consists of two related with Value process and the other three were linked to Risks. Although the findings were concerned to the implementation of the integration of those two techniques, in accordance with improvement during the design phase, some possible limitations are expected to exist, for example, time consuming to the extended process. In addition, education along with training is needed to the prosperous of the integrated approach.

Keywords*: value engineering, risk management, integrated, construction project, design phase*

INTRODUCTION

Background

Projects within the construction industry are subject to unique features of construction activities, and by definition, "*a project is a temporary endeavor undertaken to create a unique product, service, or result*" (PMI-PMBOK, 2008). A project has two main milestones, a definite beginning and end. Between those two milestones, specific activities take place in a collection of sequential phases in the, so called, Project Life Cycle (PLC). Design is on one of those phases (design phase), prior to the construction phase. Each project has certain objectives, mostly established since the beginning. During the design phase, the requirements of the client are identified within the constructive aspects and the standards of quality. According to Zou et al. (2008), managing risks in construction projects is important while "Value methodologies can be applied during any stage of a project's development cycle, although the greatest benefit and resource savings are typically achieved early in development during the conceptual stages" (SAVE International Value Standard, 2007 edition).

It is the intention of the study to the use of value and risk management techniques in a single integrated process during the design phase in accordance with project's performance by reaching the project's objectives.

The study has specifically been conducted on certain irrigation projects within the Irrigation Division of Public Works of North Sulawesi Province and focused on the process during the design phase. In the development of those projects, especially during construction, although quality aspects were not appeared as problems, by some means, there were changes concerning the design aspects as well as time extensions. In facts, the Designers (design consultants) were not in the position of preparing such services of value and risk management as the services were not supported and specifically stated in their consultancy contracts. If the contracts supported such services, the problems may appear on the Designers' works, as certain skills are required to do their jobs.

The research presents findings regarding impacts in using value engineering and concurrently with risk management techniques during the design phase proportionally to their importance to the project's objectives. Moreover, it is considered as important techniques to apply during the design phase since the project's outcome could be properly measured on the next construction phase.

Additional information to be added here is that those constructed irrigation projects were probably in accordance to plans and commitments from the client side and end users (mostly are farmers) without doing the integrated value and risk management during design phase. As written on the Clients' formal reports, productions of paddy fields increases as much as twice in comparison to the production prior to the new constructed irrigations' projects.

Problem Formulation

As in the background, in the light of achieving the desired result of the project objectives by integrating Value and Risk management during design phase, the formulated problems are as follows:

- What are those aspects in Engineering Design that influence project's objectives and or performance, and
- How they relate in term of their magnitudes of importance to the project parameter (limited to: Time, Cost, and Quality).

Objective of the Research

- To understand the impact of using the value and risk management on project performance
- Quantify the relation between value and risk and multi factors model for value and risk in project to finding the risk related to to project's objectives

Many reasons for applying value and risk management but the main reason is that it can provide significant benefits to reach the project's objectives

LITERATURE REVIEW

Comprehensive reviews and the substantive research have been conducted to the appropriate field of the application of value and risk management techniques using books and scientific articles prepared by professionals.

PLC (Project Life Cycle) and the Design Phase

Projects typically pass through a series of phases as they move from client need to project, including engineering design phase as it is one of those phases. "The life cycle is the only thing that uniquely distinguishes projects from non-projects," Patel and Morris, as in Widerman (2004), furthermore from the same source, the project life cycle is the sequence of phases through which the project will evolve. For the purpose of the study, Authors have created "sketches" as shown below. It shows the anticipation (dotted red arrow) on project's objectives during the design phase based upon the PLC of Widerman (2004).

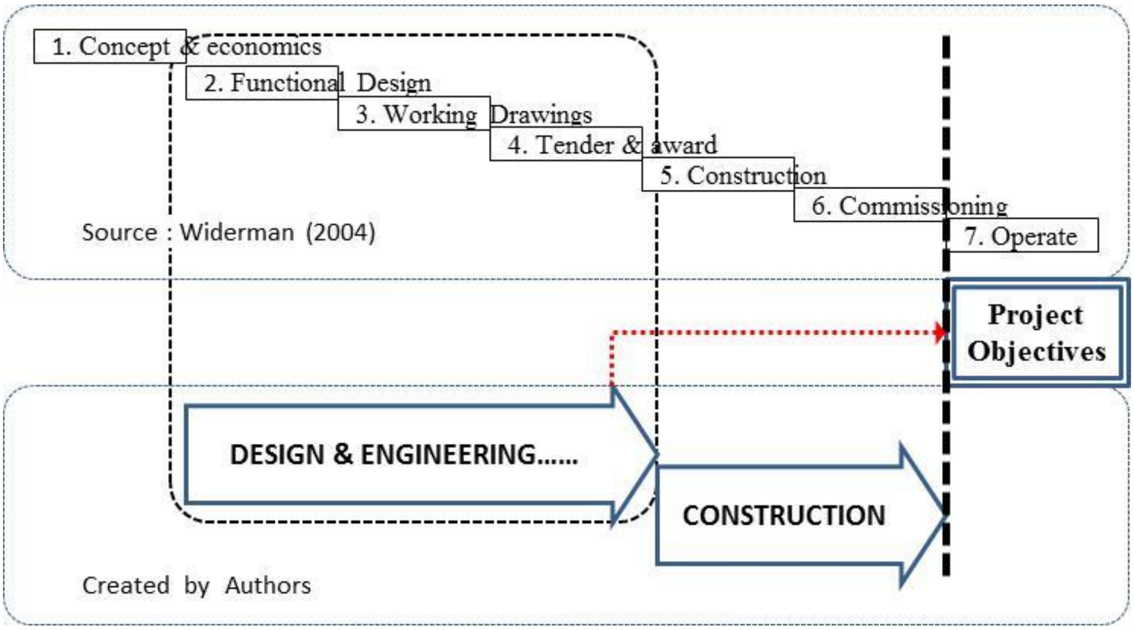


Figure 1. Overview of PLC and anticipation during Design to Project's Objectives

In the design phase–design and engineering process, all the requirements of the client are identified within the constructive aspects along with the standards of quality that are defined through procedures, drawings and technical specifications, Luis F. Alarcón et al. (1998). Design is a creative process, Oberlander (1993) not a routine one, therefore problems encountered are more complex although designing irrigation projects, as a typical civil engineering kind of process, is not a pure multi-disciplinary works, for instance, in comparison to building projects. However, during design phase, according to Alarcón et al. (1998), "*this important phase is usually carried out with little interaction between the construction and design teams causing many problems during construction such as: incomplete designs, change orders, rework, construction delays, etc.*" Although the possibility of "little interaction between the construction and design," mentioned above will depend on project delivery strategies, for example, when the delivery is using construction management approach–an overlapped design and construction phases. In the projects observed, construction activities begin upon the completion of design and tender processes. It is important though to provide the standards of the expected contractors in the construction documents and bid specifications.

In general, as on the best authors' practices, design is a multi-step including the research, conceptualization etc., establishing design requirements, preliminary design, design development, detailed design or working drawings (construction documents), and production. This multi-step is one among other aspects that is used as basic factors to observe. Factors concerned during the design phase that are references to implement value and risk management, for example, preparation, methodology etc.

Value Engineering and Risk Management – An overview

According to Dallas (2004), successful projects need value and risk management, value management deals with maximizing value and risk management fulfills effective project management in managing risk. Risk is often related to the negative and cannot be controlled as an uncertainty that can cause fatalities in any situation. Risks might occur in any situations, as in construction projects, and in every construction project, most of the owners' requirements are concerned with "time" (as soon as possible) while "cost" should at the level that they can afford. Hence, risks should be managed properly, and in accordance with the value, the project should be in the very best performance at the minimum cost as well as the shortest time in line with the project's objectives.

Value Engineering (VE)

"Value Engineering and Value Management are sometimes used synonymously and sometimes as though they are different processes. What actually makes them different, however, is usually not defined" (KPK Research Digest – July 2012 Issue). However, the essence of Value Engineering or Value management lie in its concept of value.

Value engineering is known to reduce project cost, improve project quality, eliminate unnecessary design elements, enforce innovation, and improving productivity. VE is a systematic recognized technique, usually by independent team to identify the function of products or services, establish the worth of that function and generates alternatives. VE has the objectives in reducing construction time, safety, operational and environmental commitments, and reduced total costs. It may also suggest the use of innovative technologies to improve finished quality as well as considering long-term life-cycle costs. The process can be broken down into four components: applicability (when it is required), the team (who will do it), the job plan, and reporting recommendations. The job plan is divided into steps, information, function analysis, creative (how to accomplish the required function), evaluation (select alternatives for development), development (recommend the selected alternative), and presentation (for approval).

> *"Value is defined as a fair return or equivalent in goods, services, or money for something exchanged"*

(SAVE International Value Standard, 2007 edition). Value is a function of "Function" and "Cost" in an equation as follows:

$$\text{Value} \sim \text{Function/Resources}$$

However, Stewart et al. (SAVE International 2011 Annual Conference) introduced the "Uncertainty Modeling in Multiple Dimensions for Value Methodology," and "it is important to acknowledge the multiple sets of outcomes that may occur by introducing uncertainty." The value's expression may look as the form of:

$$Vf(P,C,t)\_total=(\sum(P\cdot\alpha)/(\sum[(C\cdot\alpha)+(t\cdot\alpha)]),$$

where, V=value, f=function, P=performance, C=Cost, t=Time, α=Uncertainty. This equation shows the multiple scenarios for performance, cost, instead of a single point estimate. Moreover, this form is then inspired this study in combining and integrating value and risk management as well as "Value Study is guided by the function-based Job Plan" (SAVE International Value Standard, 2007 edition).

The Job plan, in value engineering process, is also called as value engineering methodology, consists of orientation, information, function analysis, creative, evaluation, development, presentation, and implementation. The function analysis is as significant and important step in the development of value engineering process. Charles W. Bytheway (1965) at National Conference of the Society of American Value Engineers (SAVE) in Boston, USA, introduced classical technique called FAST (Function Analysis System Technique). FAST approach is using three questions (what is it, what does it do, and what must it do) in analyzing each function, although it can be a difficult and time-consuming effort.

Risk Management

Risk can be explained as an uncertain event, always in the future, has a cause and effects and it affects the objectives of a project. In the construction projects, discussed in the PLC, is a process, and risks might occur since there is no risk free during that process. According to David Hillson, an expert in risk management, risk management intuitively is asking and answering some basic questions like "what," "why" etc. These series of questions will be steps in managing risks i.e.: risk identification, assessment, evaluation or analysis, response, tracking-monitoring-control, and learnt. By doing this, project can be improved in meeting its objectives. Risk management may be described as "a systematic way of looking at areas of risk and consciously determining how each should be treated. It is a management tool that aims at identifying sources of risk and uncertainty, determining their impact, and developing appropriate management responses" (Uher, 2003, in Zou, 2008). A systematic process of risk management has been divided into risk classification, risk identification, risk analysis and risk response, where risk response has been further divided into four actions, i.e. retention, reduction, transfer and avoidance (Berkeley et al., 1991; Flanagan and Norman, 1993, in Zou, 2005). Zou also identified twenty major risk factors in construction projects, and stated that those risks spread through the whole project life cycle. Risks related to designers are as follows, design variations, variation by the client, inadequate program schedule, and inadequate or insufficient site information (soil test and survey report).

The Integration of Value and Risk Management – during design phase

According to Dallas et al (2004), successful projects need value and risk management, value management deals with maximizing value and risk management fulfills effective project management in managing risk, even though, those techniques have been used separately Feili et al. (2012).

Montanah et al (1998) created a chart of "the possible interface" between risk management and value management. There are four groups in risk management,

a. pre-study
b. this group consists of identification and categories, assessment, and preliminary risk mitigation
c. the third group is divided into risk analysis of value management alternatives, finalize risk, and response strategy
d. post-study

then value management consists of:

(1) pre-study; (2) information phase; (3) function analysis; (4) creative; (5) evaluation; (6) development; (7) decision; (h) presentation; and (9) post-study. The original chart had been re-arranged for the purpose of simplification as in figure 2, as follows:

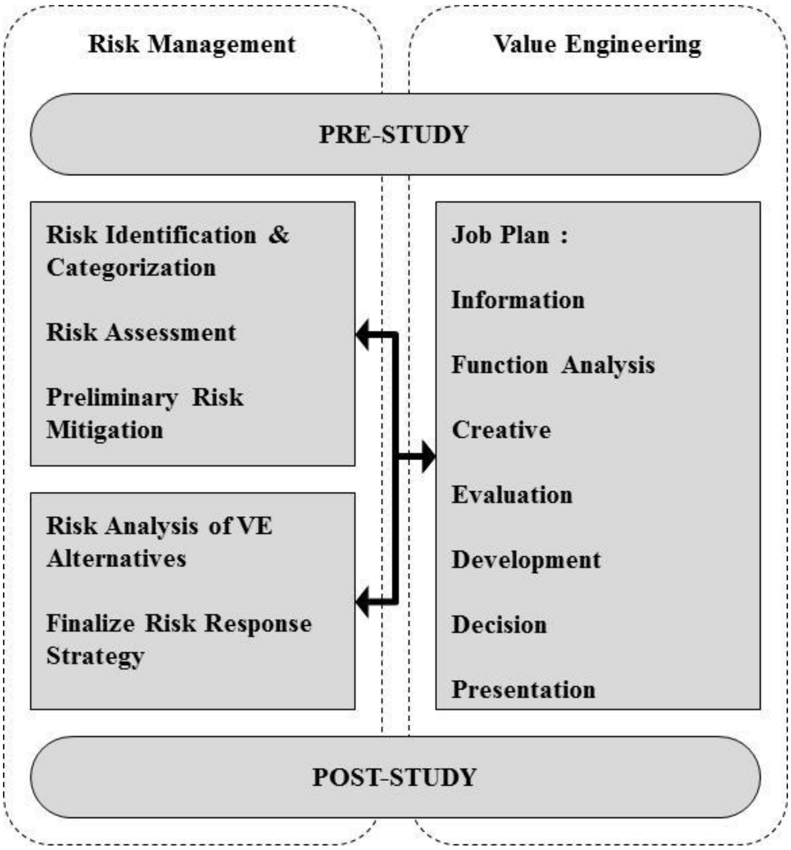


Figure 2. Source: Devadass P. Montanah et al (1998) – Simplified by Authors

The simplified chart is intended to look at the alternatives created in value engineering job-plan steps as an important "output" which is integrated to risk analysis in risk management process. In the original chart, the interesting part is that risk analysis has been applied to the result of value engineering alternatives.

Having reviewed all the required materials regarding value and risk management processes, the authors found, theoretically, that the integration between the two recognized tools can be explained, in a simple way, in line with the project's objectives, is as shown in figure 3.

It is also, as a kind of remainder for project's team during the design phase, to keep in mind, that every construction project, in this case irrigation project, has no risk free and always aware with their results in designing as the best alternative among all possible alternatives, to reach project's parameter i.e., "time," "cost," and "quality."

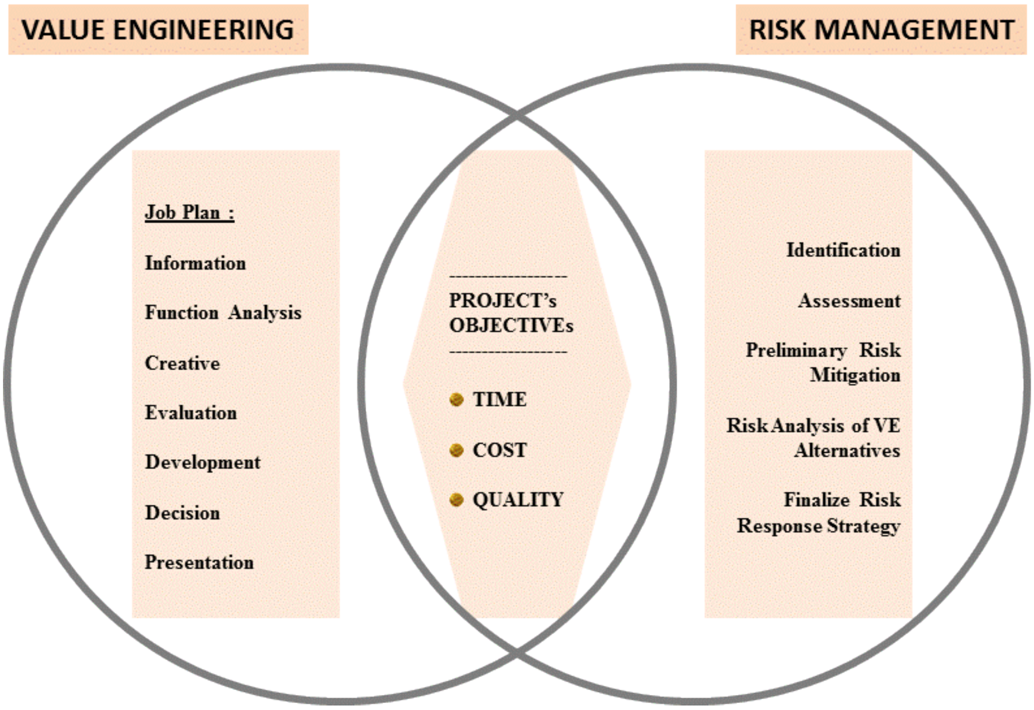
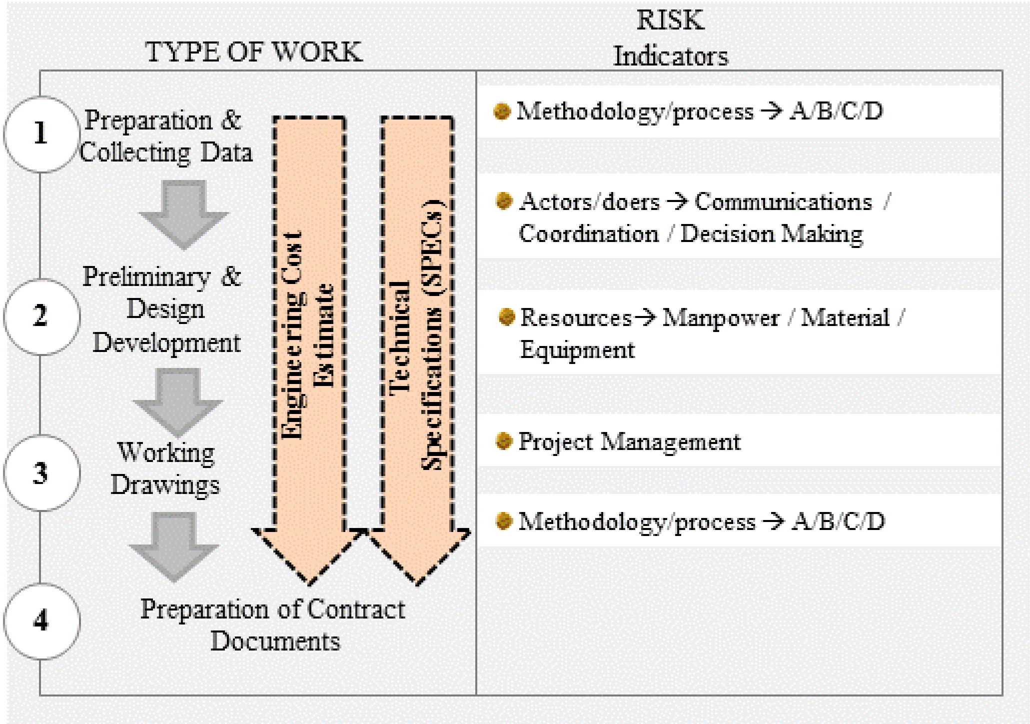


Figure 3. Integration of value engineering, risk management, and project objectives.

RESEARCH METHODOLOGY

Past research regarding the integration of value engineering and risk management has been done as Karim et al (Quantity Surveying International Conference, 4-5 September, 2007 Kuala Lumpur, Malaysia), explored the research methodology with procedures and process of value and risk management used by selected organizations, analyses the application of potential in the implementation of value and risk management. In this study, methodology selected, based on and started by indicating the type of work as well as risk indicators or factors, as in figure 4. In fact, based on formal written documents (reports), most of the designers used their design methodology as in figure 5. Firstly, concerning the value-engineering techniques in this study, in proportion to the designers' methodology, the idea is inspired using chart from SAVE (2007, edition). It has focused on "value job plan," and the important assumptions were made regarding the "alternative selection" and "best alternative" that they had actually been practicing the value concept although it was not as formal steps in value engineering method. Therefore, questionnaires were created based on the assumptions that most of the respondents aware of choosing "best alternative" in any aspects concerned. Secondly, risk management as Hillson (www.who.int/management/.../risk/WhenRisk...), expert in risk management, "the key is to realize that risk can only be defined in relation to objectives. The simplest definition of risk is "uncertainty that matters", and it matters because it can affect one or more objectives." Therefore, risks involved in this study are assumed that matters to the project's objectives, and those are applied to the main works in the design and engineering process.



.Figure 4. Overview - type of work and risks factors

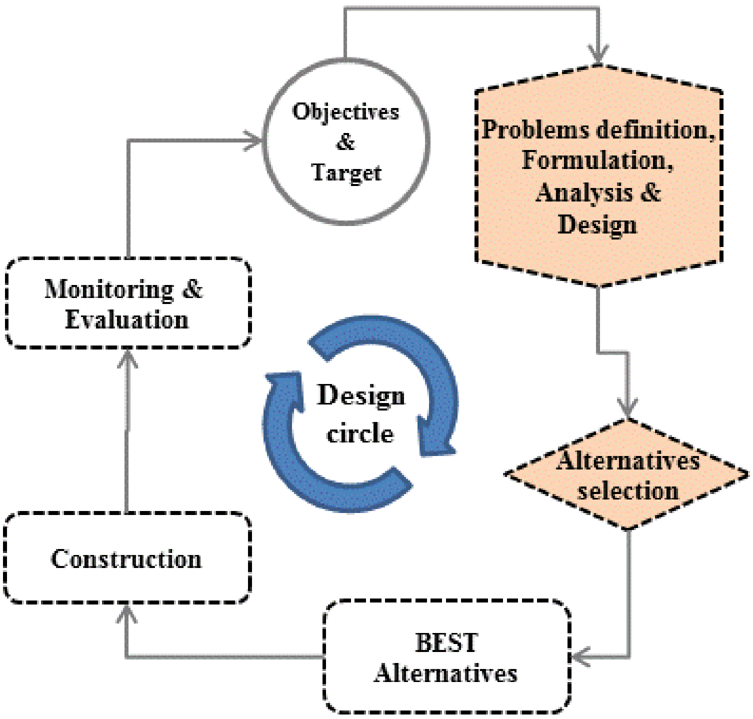


Figure 5. Design methodology (Source: Designer/Consultant)

The research methodology has been selected using theoretical framework, and questionnaires, interviews, and limited projects' documentations from Irrigation Division of Public Works North Sulawesi Province, . The survey data were used (mostly from the respondents' responses) and a statistical analysis of those data using SPSS-20. As shows on figure 6, as a model, type of works consists of four main tasks i.e.: preparation and data collection, preliminary and design development, working drawings, and preparation of contract documents. Engineering cost estimate and technical specifications (specs) are always in touch with those tasks.

Variables, independent and dependent, are assumed as in the model, even though there are various variables may exist. There are five main factors in risks i.e.: 1) methodology/proces, 2) actors/doers, 3) resources, 4) project management, and 5) regulation/standards. Function analysis, creative process, and evaluation are considered as predictors in term of "value concept" whereas each alternative is always satisfied the need and its objectives, with its wide variety of possible alternative ways to improve the value of the project, since the result warrant the time, cost , and quality. Likert scale is used to measure those variables and is a five-point scale, 1 is considered as the lowest while the highest is 5. Main factors in risks, from 1 to 5, and the level of impact, consist of 30 questions, 35 questions, 3 questions, 7 questions, and 3 questions, respectively, with the total = 48 questions, and the likelihood of occurrence, in line with value process, in term of time, cost, and quality.

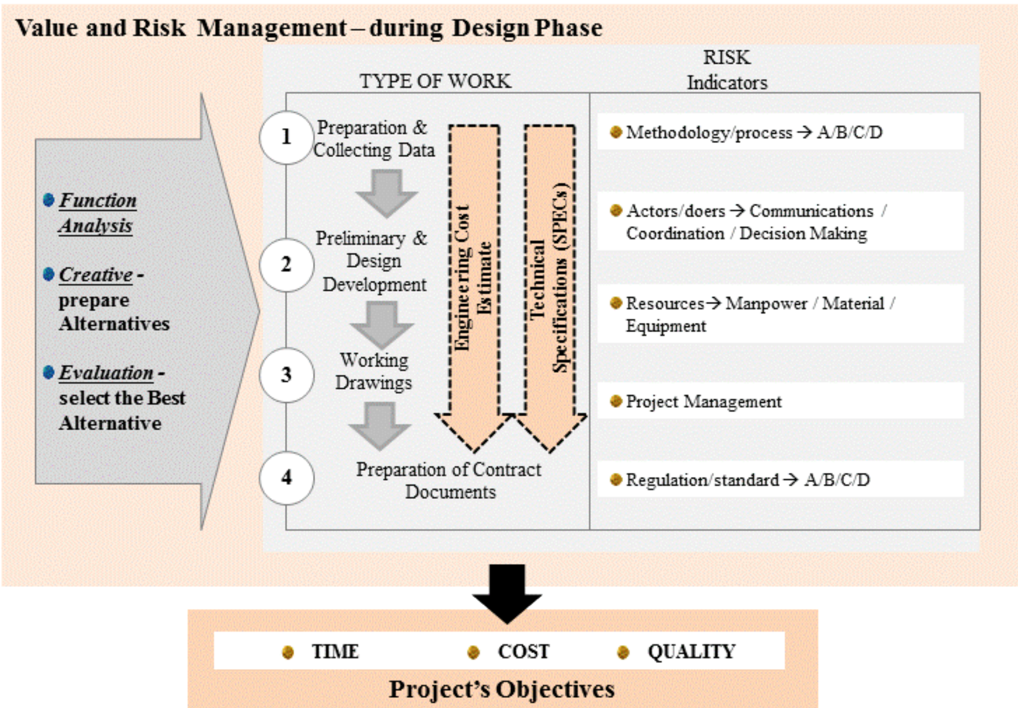
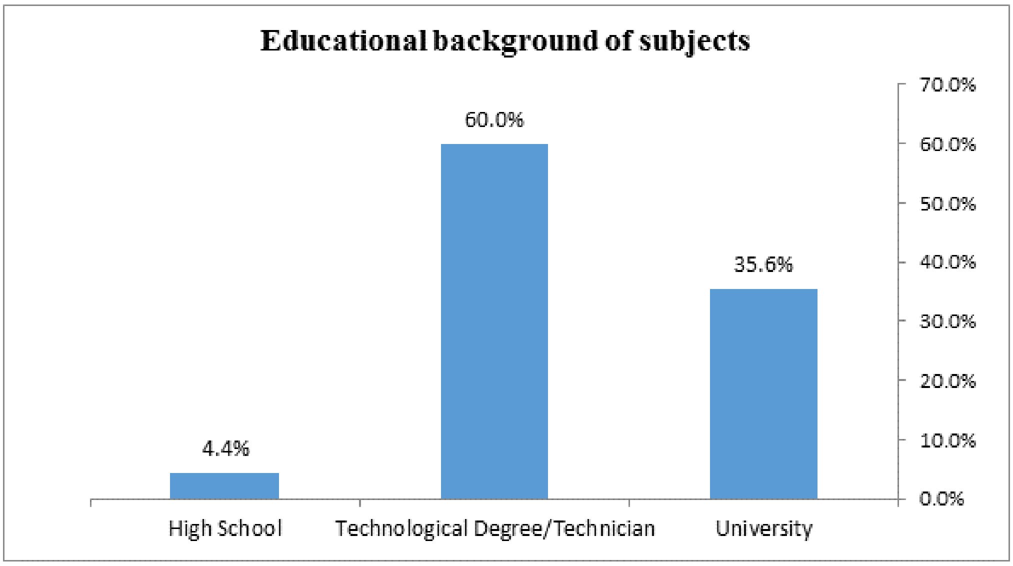


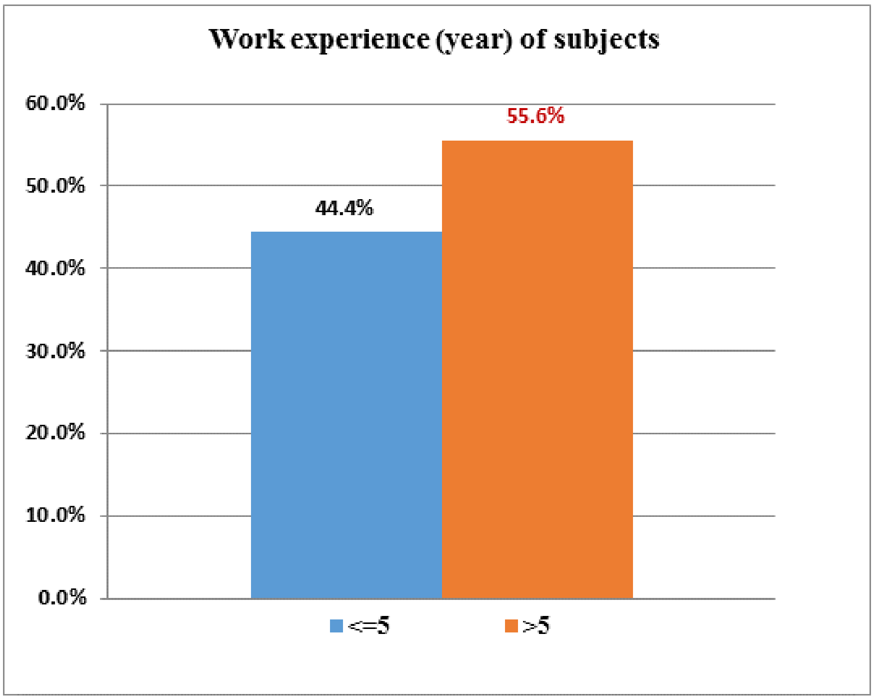
Figure 6. Research methodology concept – theoretical framework

Sample composition

The distribution of respondents consist of educational backgroud level and work experience, graduate levels = 0.00%, undergraduate = 35.6%, between high school and undergraduate (technological degree), as technician = 60.0%, high school = 4.4% (graph 1). Work experience distribution (in year): 55.6% > 5, and 44.4% ≤ 5 (graph 2).



Graph 1 Educational background of subjects

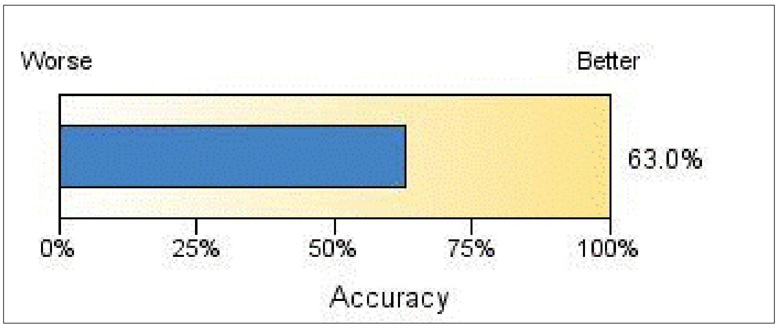


Graph 2 Work experience (year) of subjects

RESULTS AND DISCUSSIONS

The purpose of the study is mainly to identify and in measuring the magnitude of factors in considering the integration of value and risk management during the design phase in construction projects, and its implications to the project objectives, as well as its limitations as it is based upon the observed irrigation projects.

Those factors are ranked in term of their effects to project time, cost, and quality, as shown in figure 7, 8, and 9 respectively, and table 1, 2, 3…(SPSS outputs) in which significance or p-value are mostly less than 5%. Although model accuracy (the highgest) is in the level of 63% (graph 3), it is considered a “good” model since it is more than average ~ 50%, thus, it is only about 37% that model is influenced by other factors.



Graph 3 Model accuracy

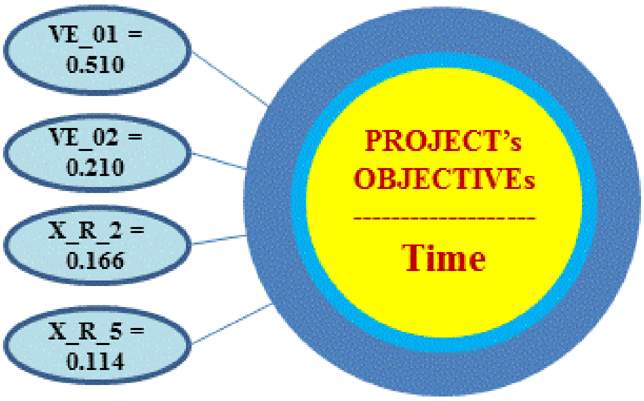


Figure 7. Factors related to project time

EFFECTs / Target: Y_T

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	0.659	4	0.165	19.698	.000	
X_VE_01_transformed	0.100	1	0.100	11.952	.001	0.510
X_VE_02_transformed	0.041	1	0.041	4.930	.032	0.210
X_R_2_transformed	0.033	1	0.033	3.886	.056	0.166
X_R_5_transformed	0.022	1	0.022	2.684	.109	0.114
Residual	0.335	40	0.008			
Corrected Total	0.994	44				

Table 1. Factors related to TIME

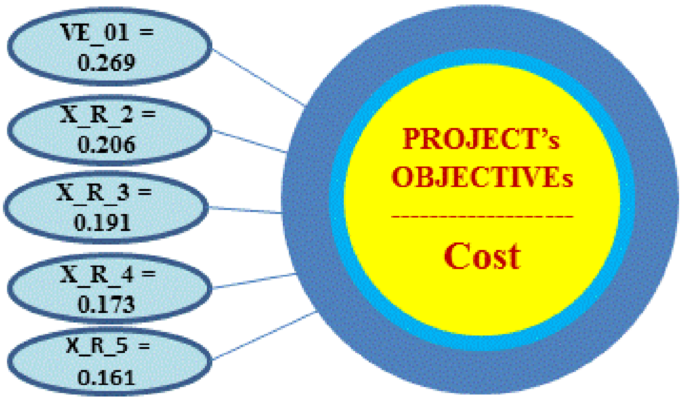


Figure 8. Factors related to project cost

EFFECTs / Target: Y_C

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	0.063	5	0.013	7.182	.000	
X_VE_01_transformed	0.014	1	0.014	8.045	.007	0.269
X_R_2_transformed	0.011	1	0.011	6.178	.017	0.206
X_R_3_transformed	0.010	1	0.010	5.721	.022	0.191
X_R_4_transformed	0.009	1	0.009	5.171	.029	0.173
X_R_5_transformed	0.009	1	0.009	4.828	.034	0.161
Residual	0.069	39	0.002			
Corrected Total	0.132	44				

Table 2. Factors related to COST

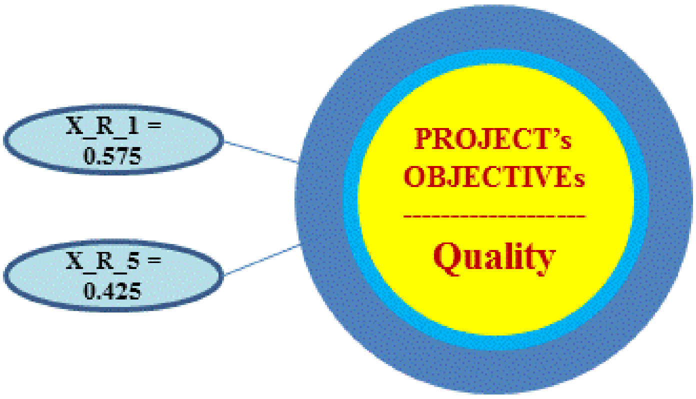


Figure 9. Factors related to project quality

EFFECTs / Target: Y_Q

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	0.042	2	0.021	4.320	.020	
X_R_1_transformed	0.026	1	0.026	5.304	.026	0.575
X_R_5_transformed	0.019	1	0.019	3.921	.054	0.425
Residual	0.202	42	0.005			
Corrected Total	0.244	44				

Table 3. Factors related to QUALITY

Other result is, by looking at factors that affecting simultaneously, as an overall, which are related to project objectives, shown on figure 10. It can be concluded that, as an overall, those two techniques (value and risk management) are important when they are applied simultaneously within the single process.

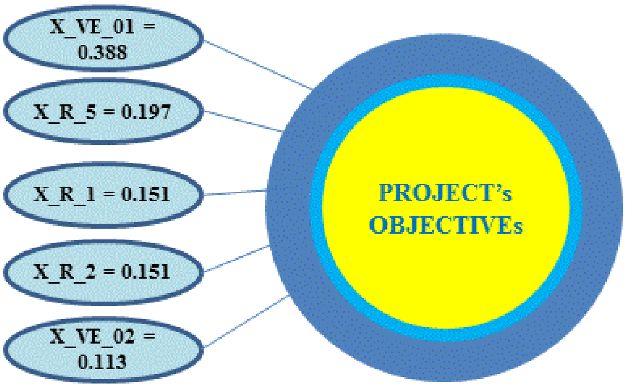


Figure 10. Overall project objectives – coefficients

Source	Sum of Squares	df	Mean Square	F	Sig.	Importance
Corrected Model ▼	0.151	5	0.030	11.793	.000	
X_VE_01_transformed	0.024	1	0.024	9.492	.004	0.388
X_R_5_transformed	0.012	1	0.012	4.817	.034	0.197
X_R_1_transformed	0.009	1	0.009	3.700	.062	0.151
X_R_2_transformed	0.009	1	0.009	3.678	.062	0.151
X_VE_02_transformed	0.007	1	0.007	2.749	.105	0.113
Residual	0.100	39	0.003			
Corrected Total	0.250	44				

Table 4. Factors related to Overall Project Objectives – Time_Cost_Quality

CONCLUSIONS

Based upon the survey with sound industry practitioners as experience and knowledge of construction projects are not in its preference level, the research were highlighted the factors and its implications to achieve the desired project objectives. As well as the integration of value and risk management to be considered to construction projects as an approach during the design phase.

The research endeavoured to identify those factors associated with the achievement of project time, cost, and quality on irrigation projects. "Functional analysis" as "efforts" was found to have significant impact on the three aspects in the project objectives while the further step "creative" rest as the second and last from those three steps being considered. The three risks seemed to be at the same level of their implications i.e.: risks that associated with design methodology and process, actors involved, and regulation or local standards, in line with value engineering process. Moreover, responses of those risks were not included in the research, as the intention lie only up to the analysis and evaluation as those two techniques are suggested to be in consideration during the design phase. Responses, in term of actions to be taken, in risk management are actually important not just its analysis and evaluation. Although the findings were concerned to the implement-tation of the integration of those two techniques, in accordance with improvement during the design phase, some possible limitations are expected to exist, for example, time consuming to the extended process. In addition, education along with training is needed to the prosperous of the integrated approach.

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