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RESEARCH PAPER

Risk Assessments in Construction of Water Supply Projects in Kurdistan Region-Iraq

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A B S T R A C T:
Water distribution systems play a critical role in supplying sufficient water to users with acceptable quantity, pressure, and quality. These infrastructures are usually designed to fulfill base demands with additional capacity for emergency conditions. To evaluate the reliability of water supply systems under threatening conditions, risk assessment has been recognized as a useful tool to identify the hazard, analyses vulnerabilities, and risks, and select proper mitigation measures. A questionnaire has been deigned including 51 factors that create risk events that can occur during construction works implementation. The Probability /impact risk rating matrix were used as basis for quantitative risk analysis to determine the most critical risks which were a great impact on project and also to indicate moderate risks that must be taken into consideration. The findings of the questionnaire indicated that the most crucial risk related to design and contract of water supply projects were improper estimate quantity and quality of water needed for each individual of customer, inaccurate selection the standard and specifications of materials, change of design because of improper understanding of customer needs, inadequate estimation of available flow and pressure of water, improper design documentation and drawings. In construction and management phase, the most significant risk factors were poor quality performance, improper quality control, inadequate safety requirements on site, and delay payment on contract. While war, military operation, terrorism attack, and inadequacy of insurance became a maximum critical risk factor as a political issue. Also force majors such as earthquake, flood and water pollution from pipes corrosion summarized as serious environment risk factors. Furthermore lack of labor skill or qualified plumper became the most critical risk must be considered during resource managing.

KEY WORDS: Risk management, Risk assessment, Water supply system
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1. INTRODUCTION

Risk management has become a necessary requirement for construction projects. Risk management consists of risk identification, risk assessment and risk control. Risk assessed by the qualitative method and quantitative method. Risk management is the organized process of identifying, analyzing, and responding to project risk and it contains maximizing the probability and consequences of positive attitude and minimizing the probability and consequences of attitude adverse to project goals, project risk is indeterminate event or condition that if happens has a positive or negative influence on project aims (Li, 2007).

Risk management is a systematic method of looking at risk and consciously determining how each should best be treated for identifying purposes of risk and uncertainty, determining their impacts and developing appropriate management risk plan and responses. Assessment of the impact of risks is a complex problem, which must be approached systematically by breaking down the task into four stages that are risk classification, risk identification, risk Analysis and risk response. (Abd, 2015).

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As the result of their complexity and uniqueness, all construction projects are vulnerable to a high risk. The condition for this risk reduction is an identification of risk events and valuation of their occurrence probability and impact (Rybka et al., 2016a)

Providing good and safe drinking water is considered a basic political issue for public health protection and must be the main objective of water supply systems. Drinking water systems are vulnerable and subject to wide range of risks. The safety of drinking water depends on a number of factors, including quality of source water, the effectiveness of treatment and integrity of the distribution system. System-tailored hazard identification and risk assessment must be considered as a starting point for system management (Vieira, 2005).

To be effective in providing safe drinking water supply system, risk management must involve the entire system from catchment to the client. If the risks unacceptable, risk mitigation measures should be applied, and replacement for risk mitigation evaluated. (Bergion et al., 2017).

Efficient risk management is of the principal importance to water utilities. Three attributes are crucial to water users which that must be adequate quantities of water on demand, must be delivered at sufficient pressure and it must be safe to use. Access to a reliable supply of drinking water and safe water quality are basic requirements of human health and economic development .In the third edition of the guidelines for drinking-water quality published by the World Health Organization (WHO), it is pointed out that a comprehensive risk management approach is the most effective way to ensure the safety of drinking water supply (WHO, 2004).

Water distribution system must satisfy all consumers' needs but are vulnerable to a range of failure types that can occur during an intentional extreme event and compromise their normal functions. It is important for the utility managers to assess the composition of the water distribution system in order to manage the threat. Normally, one would want to minimize the risk of undesirable consequences. In most cases, it is not possible to completely eliminate risk; however, one can mitigate it. (Ataoui and Ermini, 2017).

Blokker et al. (2017) studied on risk assessment during repair of drinking water distribution system; quantitative microbial risk assessment model was established to evaluate the risk due to fecal contamination results after maintenance of drinking water mains.

Rybka et al. (2016b) investigated the adverse events happening throughout the implementation of water supply and sewerage systems construction.

Ameyaw and Chan (2015) indicated most significant risk factors in Public Private Partnership (PPP) projects such as: inadequate contract design, water valuing and tax review uncertainty ,political restriction, public resistance to PPP ,construction time and cost overrun, non-payment of bills, absence of PPP experience ,financing risk, imperfect demand forecasting.

Zhang et al. (2014) studied on risk assessment of long-distance water supply system and stated that the maximum serious risk internal reason of water supply system was water hammer, and to eliminate the potential risks of a pipe burst, water hammer was computed under different conditions.

Chan et al. (2014) identified and evaluated typical risks related to Public Private Partnership projects in the Chinese water supply sector. The discovers displayed that completion risk, inflation, and price change risk have a higher impact on Chinese water public-private partnership projects.

Roozbahani et al. (2013) studied on risk assessment from tap to source of urban water supply systems that was usually subjected to a multiplicity of undefined threatening hazards. These threats differed to three main groups of natural, human-made, and operational hazards, which influence water quantity or water quality.

Tchórzewska-Cieślak (2011) applied a fuzzy logic based method for risk assessment of drinking water system by defining the fuzzy rules between likelihood of pipe failures, consequence of failure, and sensitivity of water mains, drinking water technical system is an essential element of urban infrastructure.

Wibowo and Mohamed (2010) investigated of risk critically and allocation in privatized water supply projects in Indonesia and discussed the perception of regulator and operator in the term of project risk critically and allocation and both regarded to the principal concerned which was non-availability of raw water.

Zeng et al. (2008) studied risk factors in build-operate-transfer BOT water supply projects in China, because of increasing population had pressure on existing infrastructure facilities, the lack of which would down economic development and social growth, in order to encouraged infrastructure supplies from the private sector the Chinese government had discovered the system BOT model operating the analytic hierarchy process (AHP) technique, constructs a three-level hierarchy for determining the critical risk factors for water supply projects.

Sadiq et al. (2007) studied on the evaluation the risk of water quality failures in a distribution network, each basic risk item in a hierarchical framework were stated by a triangular fuzzy number, which was originated from the composition of the likelihood of a failure event and the associated failure consequence.

In order to evaluate the reliability of water supply systems under threatening conditions, risk assessment recognized as a useful tool to identify the hazard, analyses vulnerabilities, and risks. Therefore, the present paper aims to indicate most critical and significant risk factors that have a great influence on water supply projects. In addition, it aims to identify and assess of risks during the implementation of water supply projects by determining the probability of occurrences and their impact of factors.

2. RESEARCH METHODOLOGY

In order to achieve main objective of this paper a review of the literature was conducted to investigate risk and identify the risk factors and sources in water supply system of construction project. Risk assessed by qualitative risk management (RM) and one method of qualitative (RM) is questionnaires. The questionnaire used as a simple and effective way for purpose of data collection, it was consisted of two sections, first section solicited general information about respondents such as year experience and profession , and second section carried a total of 51 risk factors associated to construction of water supply system and asked respondents to indicate the probability of occurrences of these risk factors and impact on construction of water supply system .These risk factors were sourced from a wide range of literature including journal paper and books worldwide as well as those specially focused on construction of water supply system. The 51 risk factors were categorized into five groups with ten risk factors related to design and contract phase, twenty one related to construction and management phase, three related to financial risks, five associated to political risk, five linked to environment risk, and seven connected to resources and procurement risk. The likert scale used for assessing probability and impact were from 1 to 5 where: 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high. About 50 forms of questionnaires created and distributed in water supply projects located in Erbil city area. A total of 42 usable responds returned with acceptable percentage respondents was (84%), all the respondents carried out in water supply projects in Erbil city .The answers listed in the returned questionnaires were collated and qualitatively analyzed using the Statistical Package for Social Sciences (SPSS) version 22 and Microsoft excel 2010.

Risk score computed as the probability multiplied by impact. The range of risk score, the rating and color are assigned to indicate the importance of each risk (Westland, 2007).

0.8	0.080	0.240	0.400	0.560	0.720
0.4	0.040	0.120	0.200	0.280	0.360
0.2	0.020	0.060	0.100	0.140	0.180
0.1	0.010	0.030	0.050	0.070	0.09
0.05	0.005	0.015	0.025	0.035	0.045
Impact ↑ Probability →	0.1	0.3	0.5	0.7	0.9

Table (1) Risk Matrix (PMI, 2017)

As shown in Table 1 Risks marked in the right upper corner with red color are the risks with the greatest negative impact on the project performance. On the other hand, risks marked in the left bottom corner with yellow color are categorized with low influence and minor effect on the project performance .The remaining risks in the middle of the matrix with orange color are classified as a moderate level where the risks should be concerned, but not as extreme as the most negative risks. From this matrix, it is easy to reflect over which action to take against an evaluated risk. All risks will be ranked which facilitates to alert the most critical (Gajewska and Ropel, 2011).

3. STUDY AREA AND DATA ANALYSIS

3.1 Study Area

The study area covered the city of Erbil which is the capital of both Erbil Governorate and Kurdistan Regional Governorate; the area of Erbil Governorate is about 15074km2 , with the population of 1542421 capita and geographically distributed of 24% rural, and 76% urban (WFP VAM,2009).

3.2 Data Analysis

From Table 2 as shown below the percentage and frequency of respondents according to degree of education the same percentage of B.Sc. and Ph.D. participate in questionnaires, which was (40.5%), and M.Sc. with (19%). As indicated in Table 3 most of respondents according to role in construction project was consultant and site engineer with (47.6%) and (45.2%) respectively .Regarding to professions of respondents as shown in Table 4 also consist of the same percentage of professions in civil and water resources of respondents with (42.9%). Table 5 related to year of experience of respondents (38.1%) of respondents was year experience between 6 to 15 year and (31%) of respondents was year experience between 16 to 25 year and the same amount (31) of respondents was year experience greater than 26 year .As shown in table 6 , (59.5%) of respondents related to number of project executed in civil projects which was between 6 to 35 project and (31%) of respondents which was 5 and less than 5 project executed in civil project. Result in table 7 indicated that (42.9%) of respondents considering by number of project executed in water supply projects which was between 5 to 20 project, and (35.7%) of respondents related to less than 5 project executed in water supply project.

Table (2) Degree of Education of Respondents.

Category	Frequency	Percentage%
BSc	17	40.5
MSc	8	19.0
PhD	17	40.5
Total	42	100.0

Table (3) Role of Respondents in Construction Projects.

Category	Frequency	Percentage %
Contractor	3	7.1
Consultant	20	47.6
Site engineer	19	45.2
Total	42	100.0

Table (4) Professions or Qualification of Respondents

Category	Frequency	Percentage%
Civil	18	42.9
Mechanical	2	4.8
Electrical	3	7.1
Water resource	18	42.9
Architect	1	2.4
Total	42	100.0

Table (5) Year of Experience of Respondents

Category	Frequency	Percentage%
6 - 15 year	16	38.1
16 - 25year	13	31.0
26 year and more	13	31.0
Total	42	100.0

Table (6) Number of Civil Projects Executed by Respondent

Category	Number	Percentage%
5 and less than	13	31.0
6 - 35	25	59.5
36- 65	2	4.8
66 and more	2	4.8
Total	42	100.0

Table (7) Number of Water Supply Project Executed by Respondents

Category	Number	Percentage%
Less than 5	15	35.7
5-20	18	42.9
20-35	5	9.5
More than 35	4	9.5
Total	42	100

4. RESULT AND DISCUSSION

The results were combined in a Table 8 based on a matrix above after computing mean of probability and mean of impact for each risk factor according to equation (1) (Xu et al., 2010).

$$M= \frac{\sum(f*s)}{N} \qquad (1)$$

Where:
M = Mean of Probability and Mean of Impact
s=Score give to each risk factors by respondents ranging from 1 to 5.
f= Frequency of each rating (1-5) for each risk factor.
N=Total number of respondents.

Also risk score obtained by multiplying probability and impact according to equation (2) (Gajewska and Ropel, 2011).

*Risk Score=Probability *Impact (2)*

Such as for risk factor D1 (0.461*0.319) equal to (0.147).
For risks marked with red color, are those with the biggest negative influence on the project risk marked with orange color are those categorized with moderate level, risk indicated with yellow color are those arranged with low effect on project performance.

The most critical risk factor which had a great effect on projects according to risk rate is inappropriate estimate quantity and quality of water needed for each individual of customer and it was became a higher location as a critical risk in design stage, whereas inaccurate selection the standard and specifications of materials became the second crucial risk factors. The third most significant risk was change of design because of improper understanding of customer needs. Additionally, inadequate estimation of available flow and pressure of water and improper design documentation and drawings were indicated as a serious risk factor. All other factors were in moderate level of impact on projects.

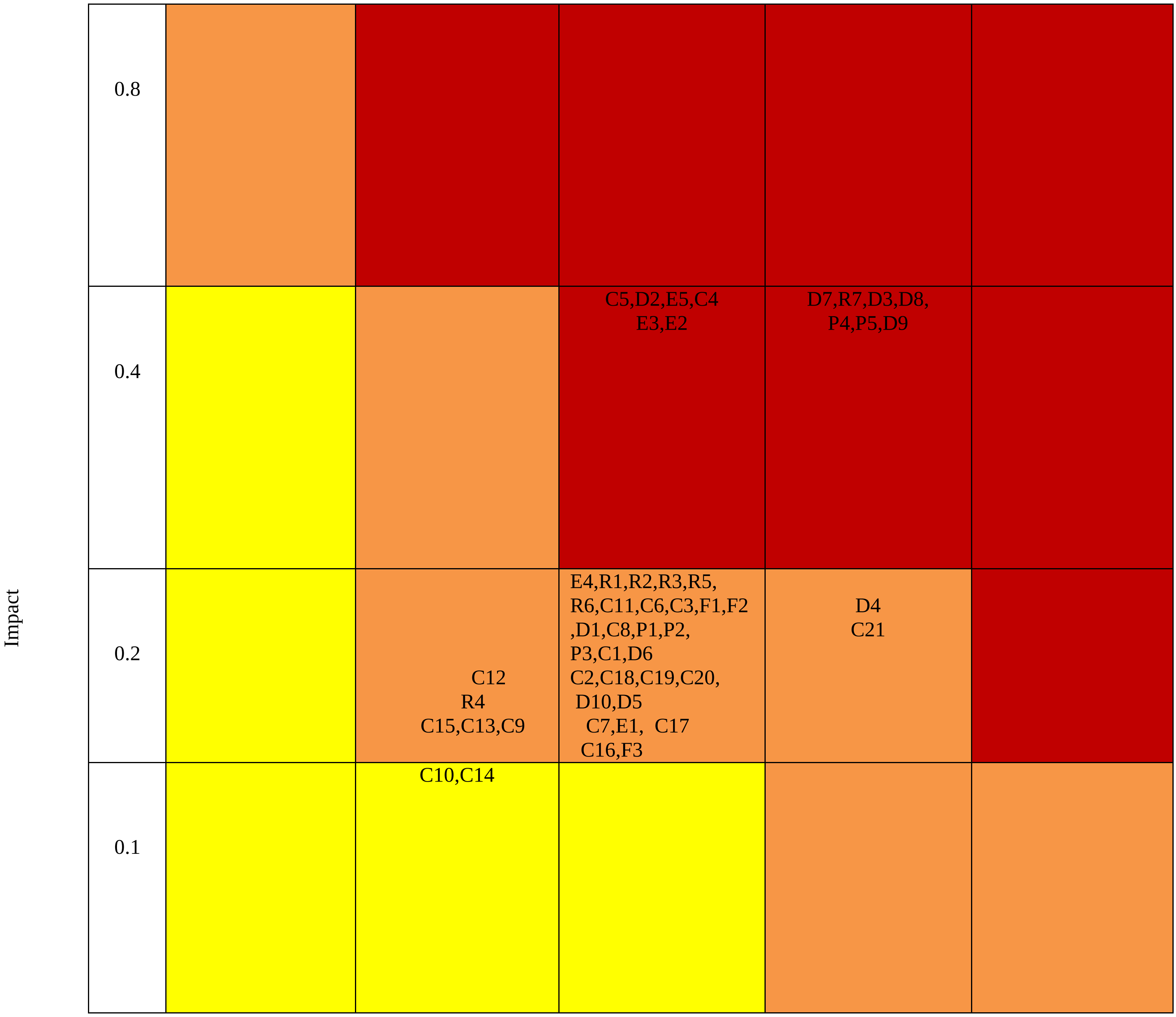
The considerable risk factors summarizes in construction stage were poor quality performance, improper quality control, afterward inadequate safety requirements on site and delay payment on contract, also there were two risk factor with low influence in project which were weakness of disputes arbitration system and inadequate of excavation work due to lack of equipment efficiency. While war, military operation, terrorism attack, and inadequacy of insurance became a maximum critical risk factor as a political issue, also force majors such as earthquake and flood, pollution of pipes from fecal animals or humans, corrosion of pipes that causes of water pollution summarized as a serious environment risk factors .Furthermore, lack of labor skill or qualified plumber became the most critical risk that must be considered throughout resources managing.

Table (8) Probability, Impact and Risk score of Risk Factors.

	RISK FACTORS	Probability	Impact	Risk Score
	1-Design and Contract Risk factors.			
D1	Poor project definition, and inadequate of project scope.	0.461	0.319	0.147
D2	Improper design documentation and drawings.	0.49	0.410	0.203
D3	Change of design as a result of inappropriate identification of customer requirements,	0.671	0.505	0.34
D4	Inadequate design check by consultant concerning the level of risks of whole project.	0.562	0.343	0.193
D5	Inaccurate cost and time estimation.	0.514	0.357	0.184
D6	Inadequate soil investigations and site survey to determine the profile of the location or site field.	0.529	0.336	0.177
D7	Inadequate estimation of available flow and pressure of water.	0.676	0.443	0.30
D8	Improper calculate quantity and quality of water necessary for each single of customer.	0.667	0.545	0.363
D9	Inaccurate selection the standard and specifications of materials (pipes, pumps ….etc.)	0.636	0.552	0.351
D10	Inappropriate form or type of the contract	0.476	0.279	0.133
	2-Construction and Management Risk factors			
C1	Construction time and cost overrun.	0.495	0.250	0.124
C2	Delays due to lack of availability of utilities.	0.452	0.202	0.092
C3	Occurrences of variations.	0.505	0.269	0.136
C4	Poor quality performance. Improper quality control	0.514	0.526	0.271
C5	Inadequate safety requirements on site.	0.481	0.424	0.204
C6	Inaccurate estimation the quantity of work in the bill of quantities.	0.495	0.248	0.123
C7	Unprofessional construction supervision.	0.476	0.190	0.091
C8	Insufficient managing of human resources by contractor or subcontractor	0.405	0.240	0.097
C9	Increases of remedial action due to absence of quality required.	0.390	0.186	0.073
C10	Inadequate of excavations works due to lack of equipment efficiency or capacity.	0.300	0.143	0.043
C11	Pipe line failures due to Inadequate welding of connections.	0.405	0.271	0.110
C12	Water leakage during distribution of pipe networks.	0.348	0.269	0.094
C13	Poor relation and disputes with partner.	0.362	0.183	0.066
C14	Weakness of disputes arbitration system.	0.343	0.145	0.050

C15	Poor coordination between head office and site offices.	0.362	0.186	0.067
C16	Change of top management.	0.419	0.169	0.071
C17	Internal management problem.	0.414	0.186	0.077
C18	Inadequate time management as a result of making change from management strategies of the project or change of project manager.	0.424	0.200	0.085
C19	Improper using available site information to provide calculated basis for risks.	0.448	0.207	0.093
C20	Poor communication and willingness to discuss risk and mitigation strategies.	0.449	0.202	0.091
C21	Delay of payment on contract	0.629	0.321	0.202
	3-Financial Risk factors			
F1	Increase in price as a result of raw materials price increase, or fluctuation in prices.	0.552	0.264	0.146
F2	Improper project planning and budgeting.	0.457	0.264	0.121
F3	Lack of skill in cost management of the project	0.429	0.157	0.067
	4-Political Risk factors			
P1	Changes in laws and regulations and permits	0.419	0.217	0.091
P2	Imperfect laws and supervision system	0.457	0.240	0.110
P3	Change in government and political opposition	0.467	0.298	0.139
P4	War, military operation, terrorism attack	0.629	0.562	0.353
P5	Inadequacy of insurance	0.614	0.364	0.224
	5-Environmental Risk factors			
E1	Skill deficiency of project managers in environmental protection.	0.429	0.231	0.099
E2	force majeure such as Earthquake, flood	0.405	0.583	0.236
E3	Corrosion of the pipes causes water pollution.	0.462	0.433	0.200
E4	Adverse weather condition or geotechnical condition	0.424	0.290	0.123
E5	Pollution of pipes from faecal of animals or human	0.486	0.417	0.202
	6- Resource and Procurement Risk factors			
R1	Purchased the Materials (pipes ,pumps, valves ,taps, connections) that don't comply with standard specifications	0.448	0.279	0.125

R2	Improper certificate of tests required for materials (pipes, pumps….etc.)	0.457	0.240	0.110
R3	The effects of defective equipment and machine quality	0.438	0.236	0.103
R4	Improper procurement plan to provide materials to site.	0.371	0.190	0.071
R5	Defect or damage of pipes during transportation, handling, fixing	0.467	0.245	0.114
R6	Labor accident.	0.471	0.357	0.168
R7	Lack of labor skill level or plumber qualification.	0.619	0.424	0.262



0.05					
	0.1	0.3	0.5	0.7	0.9

Figure1: Risk Map Matrix for Risk Factors

5. CONCLUSIONS

Risk assessment in water supply system has been recognized as a very important process, in order to achieve the most significant risks which have great impact on project. It is concluded from findings of this study the most critical risk factor which had a great impact on projects according to risk rate is improper estimate quantity and quality of water needed for each individual of customer and it was became a higher position as a critical risk in design stage, whereas inaccurate selection the standard and specifications of materials became the second crucial risk factors. The third most considerable risk was change of design because of improper understanding of customer needs. Furthermore, inadequate estimation of available flow and pressure of water and improper design documentation and drawings were pointed as a serious risk factor. All other factors were in moderate level of impact on projects.

The result of risk factors in construction stage summarizes that the most significant risk factors were poor quality performance, improper quality control, afterward inadequate safety requirements on site and delay payment on contract turn into considerable risk factors, also there were two risk factor with low influence in project which were weakness of disputes arbitration system and inadequate of excavation work due to lack of equipment efficiency.

While war, military operation, terrorism attack, and inadequacy of insurance became a maximum critical risk factor as a political issue, also force majors such as earthquake and flood, pollution of pipes from fecal animals or humans, corrosion of pipes that causes of water pollution summarized as a serious environment risk factors .Furthermore, lack of labor skill or qualified plumber became the most critical risk that must be considered throughout resources managing.

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