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Assessment of Environmental Risks in Construction Projects: A Case of Malaysia

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Abstract

Risk management is a concept which is increasingly becoming exceptional in a number of organizations. Several companies regularly set up a risk assessment procedure for performance improvement and profit maximization. In the construction industry, projects are enormously complex in nature and often involves significant budgets, and therefore reducing risks associated with project development should be key for every project manager. In this paper, risks associated with external sources have been identified and investigated in a case study. The analysis of the risks has been presented using risk priority number (RPN) to determine the failure modes in projects. From the results, the top risks included availability of labors, lack of technical know-how , use of old methodologies, inefficient dissemination of information, changes in government regulations, unrealistic contract time frame, licensing, permit, documents approvals, change of government department heads, bribery and corruption, difficulty in accessing credit facilities, obsolete technology and tools, market competition and conditions, inertia in government bureaucracies, changes in taxes, and import and export restrictions. This study aims to provide a decision tool for establishing failure modes and their priorities in Malaysian construction projects, thus, avoiding the major costly impact of the risky variables to projects in terms of budget, time and quality considering the scarce resources of construction companies.

Keywords: Construction Project, Environment, Risk, Risk Management, Risk Priority Number

1. Introduction

Risk management is a concept which is increasingly becoming exceptional in a number of organizations, from automobile companies, through IT related businesses, pharmaceuticals, service industries to the construction sector. Every industry has created their own risk management requirements, yet the underlying ideas of the concept more often do not change irrespective of the industry (Ropel, 2011). These companies regularly set up a risk assessment procedure for performance improvement and profit maximization. One of the most critical parts of project commissioning is project risk management (Winch, 2002; Project Management Institute, 2004; Potts, 2008). This demonstrates a solid relationship between risk management and project success. Even though risk management is seen as the most challenging part in construction management, its implementation is advanced in all projects to avoid adverse consequences (Potts, 2008). It ought to be restated that risk management is not a tool which guarantees success but instead a tool which builds the likelihood of increasing success.

Among the concept which is broadly utilized within the field of risk management is risk management process which comprises of four primary steps: identification, assessment, action and monitoring (Cooper et al., 2005). There are various techniques and methods in each of these steps, which facilitate handling of the risks. Many organizations have turned out to be more proactive and aware of utilizing risk analyses as a part of project development (Ropel, 2011). In like manner, risk assessment and control has become a timely issue generally discussed across organizations. In any case, this is different with respect to the construction sector (Klementti, 2006). This contradicts the fact that the sector is endeavoring to be more time and cost efficient and at the same time have more projects under control. The construction industry works in an exceptionally uncertain environment where conditions can change because of the complexities in projects (Sanvido et al., 1992). Project involves different interested groups and parties who have expertise, different stake and value system, and desired outcome (Bing et al., 2005; Ankit et al., 2013, Hannis-Ansah et al., 2016) and therefore the need for critical assessment to avoid projects failures (Aziz, 2013; Sorooshian et al., 2010; Norzima et al., 2011; Sorooshian, 2014). Even though risk management is crucial to project success, there are however many professionals who have not understood the importance of incorporating risk assessment and management in their project delivery processes (Smith et al., 2006; Ropel, 2011). Moreover, some organizations do not approach risks with established risk management methods, despite the awareness of risks and their consequences. In risk assessment, adequate prioritization and analysis of risks aids planning and management and thus, crucial for project success and better performance (Thompson and Perry, 1992; Carbone and Tippett, 2004; Abdelgawad, and Fayek, 2010; Sorooshian et al., 2010; Norzima et al., 2011; Aziz, 2013; Sorooshian, 2014).

Most studies identify causes or effects of delays without a thorough analysis and groupings (Norzima et al., 2011; Sorooshian, 2014; Hannis-Ansah, 2015). Besides, identifying the risks without establishing their failure modes and priorities would not effectively ensure reduction of the failures modes, or avoid the major costly impact of risky variables to projects in terms of time, budget, and quality considering the scarce resources of the industry. Explicitly, the existing literature has not been able to effectively address the risks in projects and that is the reason why projects are still failing (Sorooshian, 2014). Thus, there is a need for more empirical research that concentrates on the identification and prioritization of risks. This paper focuses on identification and assessment of the risks in the external environment of Malaysian construction projects. It is expected that the findings of this study would aid adequate identification and planning, budgeting and management of project-related risks. The succeeding sections of the paper is organized as shown in Figure 1 below:

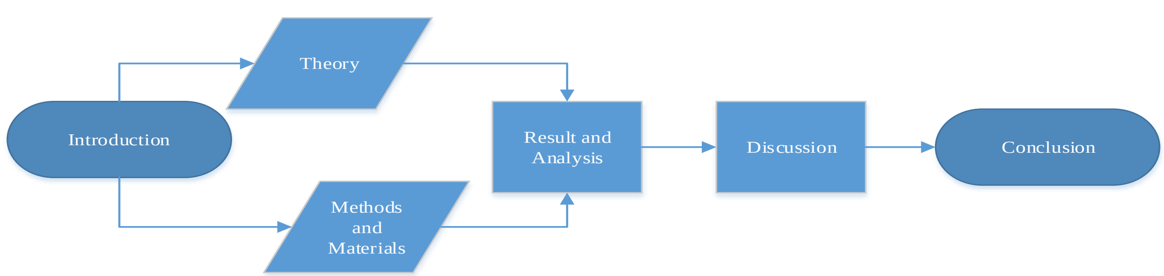

Figure 1: Outline of the Study

2. Literature Review

This section focuses on the existing literature which is positioned at the center of study's domain. Here, identification and categorization of risks including external sources of risks will be assessed.

2.1. Risks in Construction Projects

The inherent risks in construction projects present key difficulties to stakeholders and project teams (Thompson and Perry, 1992; Carbone and Tippett, 2004). In Malaysia, several risks have been reported in a number of projects (Aibinu and Jagboro, 2002; Sambasivan and Soon, 2007; Majid, 2006; Zayyana et al., 2014). These numerous records of risks in projects confirm that there is a pressing need for real causal factors identification (Singh, 2009; Norzima et al., 2011; Sorooshian, 2014; Sorooshian, 2015; Hannis-Ansah, 2015). The factors may, however, come from various sources; internal and external to the environment of the project (Arman et al., 2009).

Risk is any occurrence or action that might affect the accomplishment of project objectives (Ankit et al., 2013). Thus, risk could, therefore, be described as the influencing factor(s) that negatively impact on the time, budget, quality and the overall objectives of a project. In the construction industry, risks associated projects often cause time and cost overruns, litigation, loss of investment, settlements, total abandonment, and sometimes affect company's reputation and threaten the economy (Aibinu and Jagboro, 2002; Majid, 2006; Sambasivan and Soon, 2007; Singh, 2009). These risks must be understood, evaluated and mitigated. According to Alberto and Muhammad (2013), risk management ought to be underlined to project stakeholders to minimize failures of projects. Risk management involves the process of identification, assessment, response plan, monitoring and controlling of risks. Thus, risk management avoids failures in projects, protects and grows corporate assets, ensures profitability, enhances reputation and shareholder value (Ankit et al., 2013).

A number of construction projects have reported delays or poor performance due to evidential environmental specific issues ranging from political, economic through to ecological conditions. In order to avoid any problem within the construction project process, construction management must be circumspect of the environmental factors (Bennett, 1991; Youker, 1992; Akinsola et al., 1997; Kuye, 2004). This is because the environment interferes with the planned progress of the construction project development and therefore construction companies must understand the environment in which their system is running in order to formulate developmental strategies (Bennett, 1991; Youker, 1992; Kuye, 2004; Muir, 2005). Also, failure or success often depends on the environment (Youker, 1992).

The external risk variables come from sources outside the control of project management (Akanni et al., 2015). These sources include **Political** (Akinsola et al., 1997; Howes and Tah, 2003; Voelker et al., 2008; Al Khattab et al., 2007; Bing et al., 2005; Ling et al., 2010; Jiang, 2011; Akanni et al., 2015), **Economic** (Akinsola et al., 1997; Odeh and Battaineh, 2002; Howes and Tah, 2003; Akanni et al., 2015), **Social-cultural** (Loosemore and Muslmani, 1999; Kwak, 2002; Howes and Tah, 2003; Muriithi and Crawford, 2003; Chen and Partington, 2004; Muir, 2005; Jiang, 2011; Taherkhani et al., 2012; Enida and Vasilika, 2013), **Technological** (Akinsola et al., 1997; Goodrum and Haas, 2002), **Legal** (Martin, 2003; Jiang, 2011; Moubaydeen et al., 2013) and **Environmental** (Physical Environment) (William et al., 1992; Akinsola et al., 1997; Martin, 2003; Akanni et al., 2015). In relation to the dangers from the external environment, past studies have highlighted the need for risk analysis and management (Ankit et al., 2013).

The various risks associated with political sources include the following; terrorism, revolutions, wars, demonstrations and civil strives, nationalization and discriminatory treatments, political instability, changes in regulations, laws and policies, restrictions, bribery and corruption, expropriation, confiscation, change of government, etc. The risks associated with economic sources are; changes in taxes, changes in input prices or inflation, scarcity of materials, problems with cash flow, difficulty in accessing credit facilities, interest rates, competition, changes regulations, changes in market conditions, etc. Also, the socio-cultural risks are associated with the following; the level of education and unemployment, striking and demonstrations, the level of human rights activism, proliferation of the mass media and its independence, crimes and other social vices, attitude to work, respect for leaders, superstitions, lifestyles, and values, among others. More also, the technological sources include; obsolete technology and tools, inefficient information dissemination, lack of technical know-how, use of old methodologies, etc. Furthermore, the legal sources are; contract disputes, litigation, and arbitration, licensing and permit regulations, environment regulations procedures, unrealistic contract time frame, etc. Finally, the environmental sources include; ground conditions, weather patterns, noise, dust and lighting at the site, and others.

3. Methods and Materials

Following the literature review, the individual risks from their respective sources were identified. Meanwhile, a preliminary analysis with experts from construction companies was conducted to verify the identified risk variables. The variables were further assessed through a semi-structured interview to estimate their failure modes using the RPN method.

3.1. Risk Priority Number (RPN)

Failure modes and effects analysis (FMEA) standout among the most useful tools in reliability, as a structured technique for identifying all failure modes in a system, in dependability programs, evaluating their effect, and planning for corrective actions (Abdelgawad, and Fayek, 2010). FMEA is a reliability tool or proactive process technique for evaluating systems, designs, processes and services for potential occurrence of a failure (Thompson and Perry, 1992; Bowles, 2003; Carbone and Tippett, 2004). In the context of the conventional FMEA, the level of criticality of a failure mode is determine by computing the RPN (Bowles, 2003; Abdelgawad, and Fayek, 2010). This tool assigns numerical weightings to individual risks causing failures in systems and processes. It is connected with the use of severity, occurrence and detection indexes and RPN, and then proposes an action plan. This technique has been recommended by the international standards such as MIL-STD-1629A U.S. Department of Defense 1980 (Abdelgawad, and Fayek, 2010). A technique based on analyzing the root causes, identifying potential failures and examining failure impacts in order to mitigate the impacts.

The fundamental goal of using this tool is that FMEA-RPN presents a reliable tool for prioritization of risks associated with construction project delays and set comprehensive understanding on its detectability, probability, and severity. It calculates each failure mode and assigns severity, frequency and detectability values. By ranking the risks, project teams could identify the serious risk variables that should be solved in order to minimize the loss. This is because RPN application brings success, allowing an organization to avoid repeating costly mistakes and helping project teams to deal with the risks that occur in construction projects (Ankit et al., 2013).

3.2. Theoretical Background of RPN

The RPN analysis will be computed using Microsoft Excel 2013. The computation of descriptive statistics including the Mean will be highlighted to indicate the central measure of the tendency. Meanwhile, RPN is computed by the product of three main indicators namely: Occurrence (O); Severity (S); and Detection (D) (Abdelgawad, and Fayek, 2010; Sellappan and Palanikumar, 2013). Severity provides a numerical subjective estimate of the seriousness (effect) of risk variable to a project. Occurrence assigns a numerical subjective estimate of the frequency or probability or likelihood that a failure mode will occur in the construction project. Detection assigns a numerical subjective estimate of the effectiveness of control to identify or prevent a cause before the failure reaches the end user. RPN is given as S x O x D (Sellappan and Palanikumar, 2013).

It must be restated that RPN is not a measure of risk, but rather a risk priority. It gives a model to apply scarce resources to the most critical issues. Besides, scaling has higher priority and not necessarily higher RPN. Table 3.1 illustrates a nine-point scale adapted from Sellappan and Palanikumar (2013).

Table 1: Qualitative Scale for Severity, Occurrence, and Detection

RANK	SEVERITY	OCCURRENCE	DETECTION
1	None	Almost Never	Almost Certain
2	Very Minor	Remote	Very High
3	Minor	Very Slight	High
4	Very Low	Slight	Moderately High
5	Low	Low	Moderate
6	Moderate	Medium	Low
7	High	Moderately High	Very Low
8	Very High	High	Remote
9	Serious/Hazardous	Very High/Almost Certain	Very Remote/Almost Impossible

In the traditional approach, RPN with higher values represents higher priority (Selvan et al., 2013). In this paper, RPN is not only used to evaluate the risks but as a tool for visualizing risks priority that detect the most critical failures and provides a model to allocate the scarce resource for project failure mitigation.

4. Results and Discussion

A preliminary analysis was conducted to check the construct items, and their suitability for the Malaysian construction industry. Next, 10 key experts from a total of 11 companies responded. To ensure the experts provide reliable and comparable quantitative data, a semi-structured interview approach was used. Following the RPN method computations, as indicated above, the critical failure modes existing in construction projects in Malaysia were computed to determine severity, occurrence, and detection (see table 2).

The highest group of RPN values for political sources were recorded at 900, 840 for change in changes in government regulations and licensing, permit, documents approvals (see figure 1). Similarly, the top group of RPN values in descending order for economic sources were computed at 810 and 792 for Difficulty in Accessing Credit Facilities and Market Competition and Conditions respectively (see figure 2). Again, from figure 3, the top group of RPN in order of magnitude were Availability of Labors and Level of Education with values 1142 and 654 respectively. Also, highest group of RPN values for technological were recorded at 1140 and 990 for Lack of Technical know-how and Use of Old Methodologies respectively (see figure 4). Furthermore, the highest priorities in order magnitude with respect to legal sources were recorded at 860 and 702 for Unrealistic Contract Time Frame (UCTF) and Licensing and Permit Regulations respectively (see figure 5). Lastly, from figure 6, the top group of RPN in order of magnitude for the environment were Patterns of the Weather and Ground Conditions with values 690 and 306 respectively.

In order to determine the risk with the highest RPN, all the preferences for each expert with respect to all the sources were computed. Table 2 presents the overall group priorities. Also, Figure 7 illustrates the overall priorities and ranking.

Table 2: Overall Group Priorities

	RPN1	RPN2	RPN3	RPN4	RPN5	RPN6	RPN7	RPN8	RPN9	RPN 10	Mean	Overall RPN
Political Sources												
Inertia in Government Bureaucracies	75	105	125	105	75	105	75	27	27	45	76.4	764
Environmental & Labor Laws	75	75	45	45	9	9	1	1	1	125	38.6	386
Change of Government or Gov't Department Heads	75	75	75	105	75	75	75	75	75	105	81	810
Licensing, Permit, Documents Approvals	75	105	75	105	105	75	75	75	75	75	84	840
Changes in Government Regulations	125	45	125	125	45	105	75	75	75	105	90	900
Bribery & Corruption	175	75	75	125	75	75	45	45	45	75	81	810
Economic Sources												
Economic Growth Rates	27	75	125	175	9	45	9	9	15	27	51.6	516
Fluctuation of Prices	27	27	45	27	9	1	3	1	1	1	14.2	142
Market Competition & Conditions	27	75	75	75	45	25	75	75	75	245	79.2	792
Scarcity of Materials	27	45	75	75	45	9	45	45	27	27	42	420
Import and Export Restrictions	125	75	75	75	105	45	75	45	45	75	74	740
Difficulty in Accessing Credit Facilities	125	125	75	75	75	75	45	45	45	125	81	810
Exchange & Interest Rate Policies	75	45	45	27	45	75	45	27	75	75	53.4	534
Changes in Taxes	125	75	27	75	75	75	30	75	125	75	75.7	757
Change in Fuel Prices	27	27	45	27	45	9	27	9	27	1	24.4	244
Social Sources												
Age Distribution	27	45	27	45	9	9	3	9	9	125	30.8	308

Availability of Labors	105	75	105	147	75	105	75	245	105	105	114.2	1142
Level of Education	27	75	75	75	75	75	75	75	75	27	65.4	654
Level of Unemployment	27	45	45	45	45	27	45	27	27	27	36	360
Attitude to Work and Respect for Leaders	27	45	15	25	45	9	27	9	9	27	23.8	238
Technological Sources												
Obsolete Technology & Tools	105	75	75	105	105	75	45	45	75	105	81	810
Inefficient Dissemination of Information (IDI)	125	75	125	125	75	125	75	75	75	105	98	980
Lack of Technical knowhow	175	175	105	105	75	75	175	75	75	105	114	1140
Use of Old Methodologies	125	75	125	125	105	75	75	75	105	105	99	990
Training Programs on Technology	75	45	45	27	9	45	9	9	75	27	36.6	366
Availability of Equipment, Tools & its Parts	27	45	27	45	45	27	27	27	27	27	32.4	324
Legal Sources												
Contract Disputes, Litigation & Arbitration	27	45	45	75	27	9	9	3	9	9	25.8	258
Licensing and Permit Regulations	27	75	105	75	105	75	75	45	45	75	70.2	702
Environment Regulations Procedures	27	27	27	27	9	27	9	9	9	75	24.6	246
Unrealistic Contract Time Frame	75	75	105	125	75	75	105	75	75	75	86	860
Environmental Sources												
Ground Conditions	9	25	25	75	15	27	25	15	15	75	30.6	306
Patterns of the Weather	75	45	45	75	75	105	35	35	75	125	69	690
Level of Noise, Dust & Lighting at Site	1	27	3	3	27	9	27	9	9	9	12.4	124

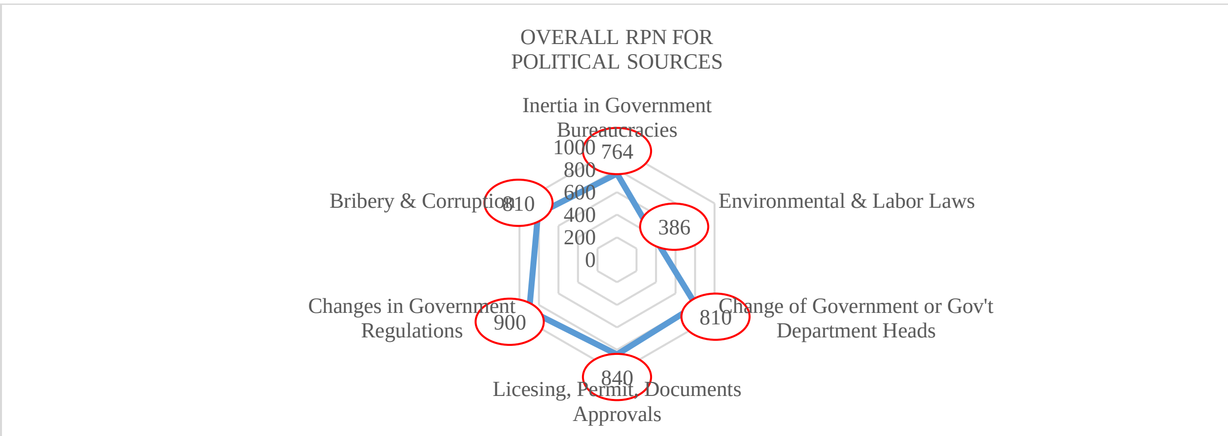

Figure 1**:** Overall Priority for Political Sources

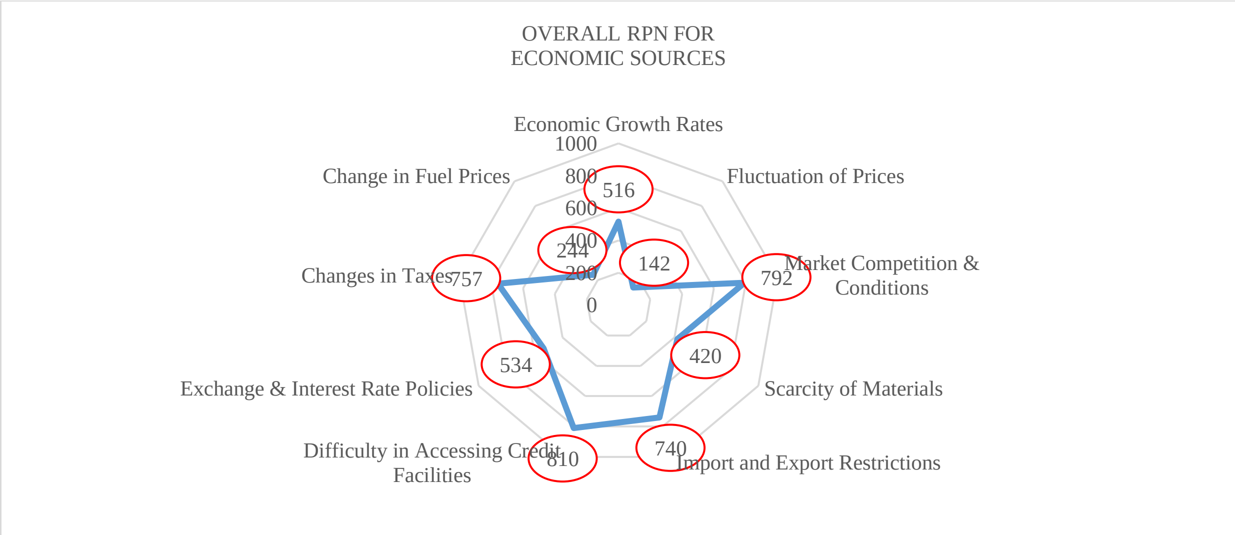

Figure 2: Overall Priority for Economic Sources

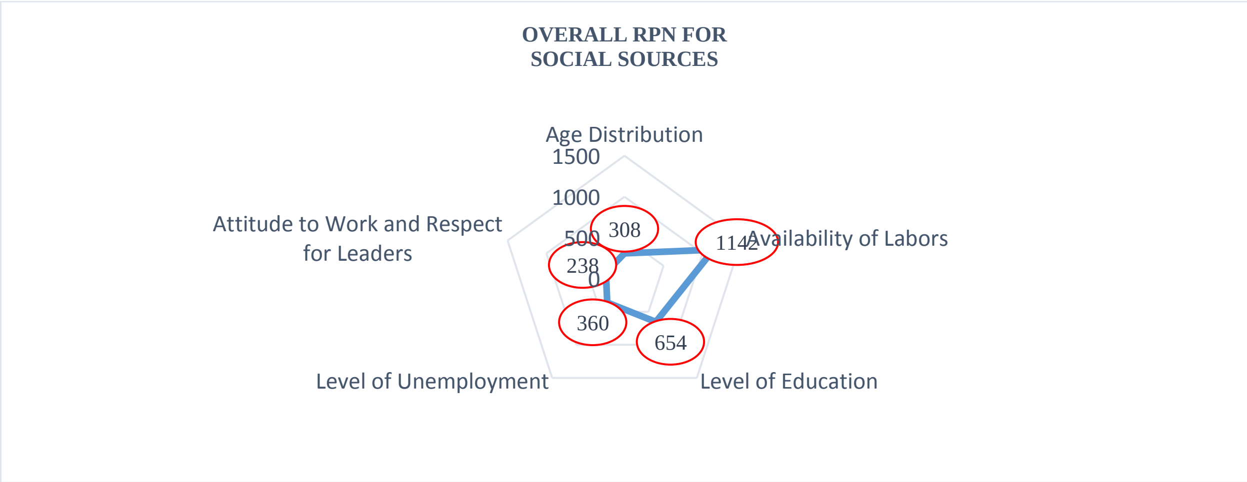

Figure 3: Overall Priority for Social Sources

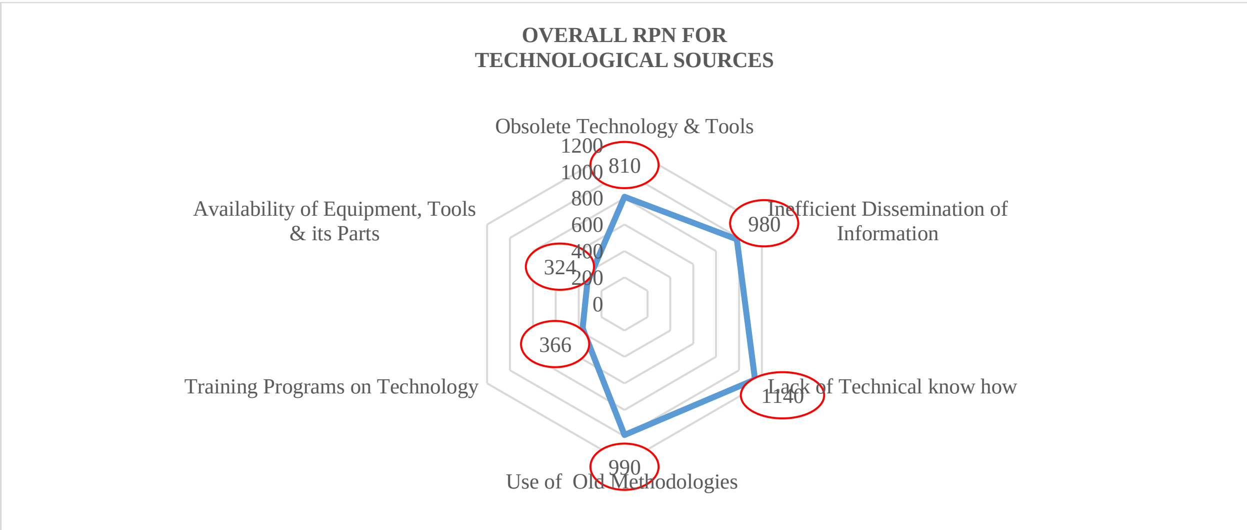

Figure 4: Overall Priority for Technology

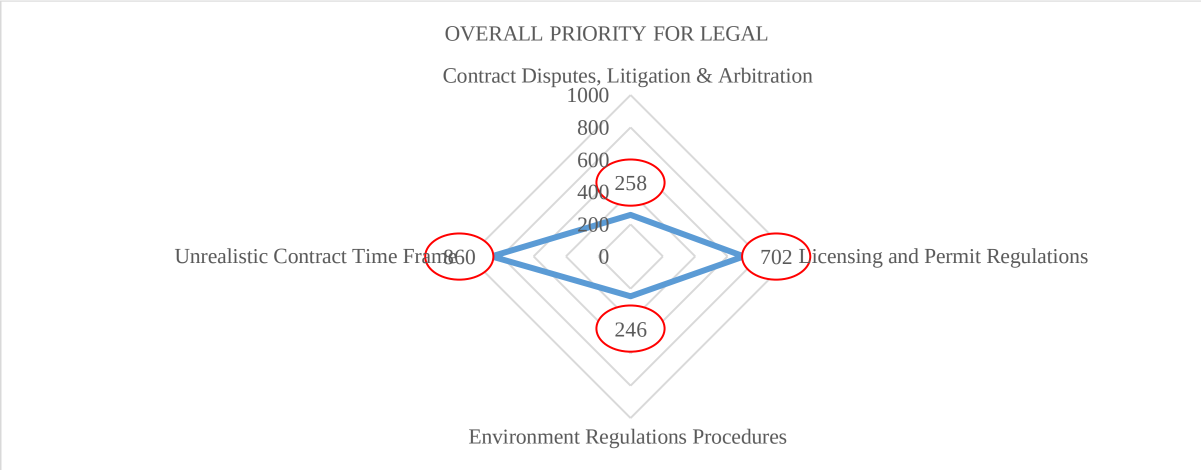

Figure 5: Overall Priority for Legal

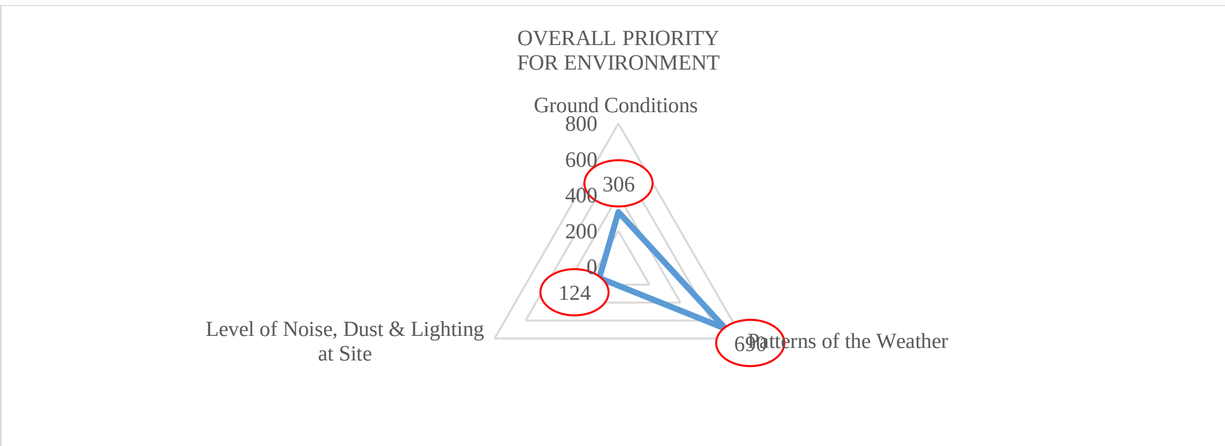

Figure 6: Overall Priority for Environment

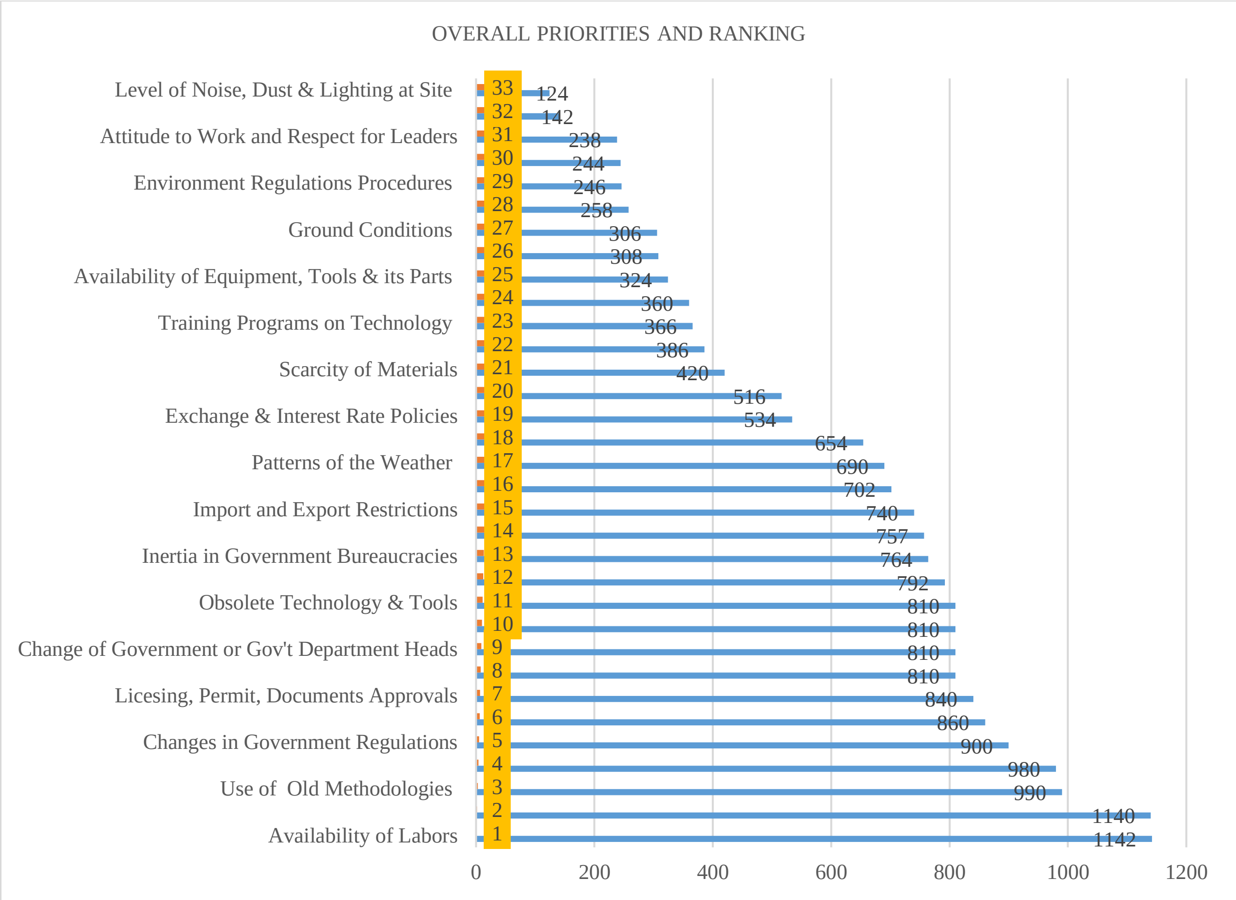

Figure 7: Overall Priorities and Ranking

The assessment of the risks in the Malaysian project development cycle based on RPN is realized. The risk in the external environment was observed to be emanating from sources including political, economic, social, technology, legal and the physical environment. The overall top five risks in descending order include availability of labors, lack of technical know-how, use of old methodologies, inefficient dissemination of information, changes in government regulations, meanwhile, the lowest risks in descending order were level of noise, dust & lighting at site, fluctuation of prices, attitude to work and respect for leaders, change in fuel prices and environment regulations procedures respectively.

5. Conclusion

In this paper, RPN was used to assist in risk assessment in the external environment of the Malaysian construction projects. To ensure every aspect of the identified risks is captured, the study identified the sources of the risks and then further identified the individual risks associated with the sources. A semi-structured interview as a data collection approach and an analysis of the results was made. The findings from the analysis showed availability of labors, lack of technical know-how, use of old methodologies, inefficient dissemination of information, changes in government regulations as the most highest risks. The findings from this study would serve as a guide and method for construction companies planning to evaluate their current project state, thus, determining the major risks and allocating reasonable resources and efforts to reduce the risks in project development. Overall, the study makes a significant contribution to knowledge, risk identification and assessment, and if well understood, would maximize project value, quality as well as reducing time, cost, and a better performance in Malaysian construction industry.

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