Identification of Risk in Green Building Projects based on the Perspective of Sustainability

XIANG Tao[1],SHU Xiang-Yuan[2]

[1,2] School of Management, Northwestern Polytechnical University, P.R.China, 710100

972848719@qq.com 13139383@qq.com

Abstract. The green building project has developed rapidly in China in recent years. The government also has many policies to preside over the development of green buildings. At the same time, green buildings are also popular among the people. With the increasing number of green building projects, the risk management of green building projects has become more and more important. Managers should fully identify risks and take precautions before the project is conducted to avoid the negative consequences that these risks may bring. This study aims to identify green building projects' risk factors based on the perspective of sustainability. For this purpose, an extensive literature review was conducted and a total of 19 factors were identified, and then a questionnaire was designed and submitted to 10 experienced green building management experts. Based on data obtained from experts, it was found that" Lack of experienced managers in the operational phase" and "The public's satisfaction with the project is very low" are the two most severe risks.

1. Introduction

As we all know, the construction industry is a typical large-scale energy-consuming industry, and its construction, operation, and maintenance all require a lot of energy. According to statistical analysis, human beings consume more than half of the total material obtained from nature when they build various types of buildings, and buildings consume nearly half of the world's energy in the process of construction and use. The air pollution, noise pollution, light pollution, and water pollution that related to the construction accounted for 34% of the total environmental pollution, and the proportion is very large[1]. In China, the strategy of sustainable development is the major development strategy. The sustainable development of resources is an important condition for all sustainable development strategies, and it is an important factor constraining sustainable development, however, 95% of the newly-added housing constructions in China each year are high-energy-consumption buildings[2], and the average energy consumption is 2-3 times that of developed countries. Therefore, the huge energy consumption and greenhouse gas emissions in the construction industry has become a "stumbling block" for the transformation of China's national economy to "energy saving, high efficiency, and environmental protection". Therefore, reducing energy consumption in the construction industry is of great significance to sustainable development in China and even in the world. So focusing on developing green buildings which is low-cost, high-efficiency, economical and environmental-friendly is an important measure for China to move toward sustainable development. From assessment standard for green building proposed by Housing and Urban-Rural Development Department in 2006 and 2014, and some policies that encourage the development of green buildings proposed by the central government and local governments ,we can see that both the central government and local governments have realized the importance of green buildings. With the continuous deepening of the implementation of green

buildings in China and the country's increasing support for green buildings, China's green buildings will continue to develop rapidly in the coming years. However, due to the low level of popularity of green buildings in China and the poor environmental awareness of the general public, moreover, the green building project also have the characteristics of long construction period, large investment, large number of participants. Therefore, the managers of green buildings in China need to do a better job of risk management, and the identification of project risks among them is a top priority. If it is not possible to determine in advance the risk of green building projects, then these risks may have a serious impact on the projects operation and may even hinder the achievement of the project's goals. Therefore, it is essential to fully identify risks in the green building projects. In recent years, many scholars at home and abroad have conducted research on the risk identification of green building projects. Wang Jinghui and Qin Xuan use system dynamics to establish a risk identification feedback model for green building projects from the perspective of the contractor to help the contractor identify key risk factors for green buildings[3]. Qin Xuan and Jing Lei.. proposed to analyze the risks of China's green building projects based on the stakeholder and life cycle perspective, and proposed risk response strategies for the top 20 key risks[4]. Xianbo Zhao, Bon-Gang Hwang , Yan Gao used Fuzzy Comprehensive Evaluation Method to Identify and Analyze Singapore Green Building Project Risk[5] .After reading a large amount of literature, it was found that although some articles mentioned the concept of sustainable development, few articles would use a sustainable perspective to identify risks, and green building projects are actually closely related to sustainable development. Therefore, this paper will adopt a sustainable perspective and identify key risks.

In this context, this paper are written through extensive reading and analysis of relevant literature and combining the assessment green building standards proposed by the Chinese government in 2014[6], and putting forward 19 risk factors from four perspectives of economic sustainability, social sustainability, environmental sustainability, and management sustainability. Then these risk factors' probability(P) and degree of influence(I) are assessed by 10 experts and then using the risk criticality index[7][8] and the results of the assessment to sort these risk factors.

2. Research Methodology

The main research methods of this paper are as follows:

(1)Through extensive reading and analysis of relevant literature and combining the assessment green Abuilding standards proposed by the Chinese government in 2014, this paper put forward 19 risk factors from four perspectives of economic sustainability, social sustainability, environmental sustainability, and management sustainability, and forming a risk assessment system based on the perspective of sustainability.

(2)Distributing survey questionnaires to 10 experts who have experience in green building projects, and collecting the data of the importance, frequency and severity indices of these risk factors on the green building projects, and then use the risk criticality index to rank risk factors.

(3)Analyzing the results and presenting some ideas for risk management of green building projects.

2.1. Risk factors

After extensive reading of the literature on risk identification of green building projects, these risk factors affecting green building projects are presented in Tab.1

Tab.1 Risk factors affecting green building projects

Risk factors affecting green building projects
1. economic sustainability
Operational performance fails to meet the objectives of the project[9]
Change of government support policy[10]
Green building market demand forecast is not allowed
Increase in the cost of green building projects

Inflation[11]
The cost of conducting a green building standard assessment becomes higher
2.Social sustainability
Poor habitability
The public's satisfaction with the project is very low
Having negative impact on Society
Poor construction environment
Construction accident[12]
3.Environmental sustainability
Insufficient on-site investigation resulted that not adjust measures to local conditions[13]
Project evaluation results did not reach the expected level
Green building energy efficiency has not reached the expected level[14]
Unstable performance during green building operation
4.Management sustainability
Lack of experienced managers in the operational phase[14]
Irrational responsibilities assignment matrix[15]
Poor organization and coordination ability of managers[16]
Labour disputes[17]

2.2. Questionnaire Design

After identifying and classifying risk factors, a questionnaire consisting of 25 questions was designed. The questionnaire has two parts. The first part involves 6 questions, asking the age and educational background of these 10 experts, and the time they spent on traditional construction projects and the green building projects, and the traditional construction projects and the green building projects that them have experienced. The second part contains 19 questions and these questions are intended to ask about the risk probability of occurrence and degree of influence of those risk factors in green building which are carried about above. For each risk factor ,experts were asked to assess the risk probability of occurrence and degree of influence based on a 5-point Likert scale(1 = rare; 2 = unlikely; 3 = moderate; 4 = likely; 5 = almost certain) for risk probability of occurrence; and (1 = very low;2 = low; 3 = average; 4 = high; 5 = very high) [17] for degree of influence according to their own knowledge and work experience. As shown in the Tal.2 and Tab.3 below.

Tab.2 Likert scale of probability of risk factor

probability of risk fator	Value
almost certain	5
likely	4
moderate	3
unlikely	2
rare	1

Tab3. Likert scale of degree of influence

degree of influence	Value
very high	5
high	4
average	3
low	2
very low	1

2.3. Data Analysis Methods

Reliability analysis that uses the internal consistency method, namely Cronbach's alpha (α), was conducted using the statistical package SPSS® in order to test the reliability of the questionnaire[18]. The standardized Cronbach's alpha can be found using the formula in Equation 1.

$$\alpha=\frac{K}{K-1}(1-\frac{\sum_{i=1}^{K}\sigma_{Y_i}^2}{\sigma_X^2}) \quad (1)$$

where K is the number of risk factors, σ_x^2 is the variance of the observed risk factor scores, and σ_{Yi}^2 is the variance of risk factor i.

In exploratory studies, it is commonly acknowledged that a value of at least 0.60 for Cronbach's alpha assures that the scale is reliable[19]. One or more of the variables that define the construct may have to be deleted in order to increase the value of Cronbach's alpha in the case that Cronbach's alpha is lower than 0.60[19].

In the questionnaire, experts were requested to assess the P and I of each risk factor. To portray these risk factors accurately, a risk criticality (RC) index was adopted. The RC of a risk factor can be computed using the following equations:

$$RC_j^i = P_j^i \times I_j^i \tag{2}$$

$$RC^i = \frac{1}{n}\sum_{j=1}^{n} RC_j^i \tag{3}$$

where n is the number of experts, P_j^i is the probability of risk factor of risk factor i by experts j, I_j^i is the degree of influence of risk factor i by experts j, RC_j^i is the risk criticality of risk factor i by respondent j, and RC^i is the risk criticality of risk factor i. As the P and I were assessed based on two five-point Likert scales, the computed RC is an index on a scale of 25[20].

3. Finding and Discussion

In order to test the internal consistency reliability of the generated scale used in the questionnaire, Cronbach's alpha values were calculated via SPSS 23.0 and are presented in Tab.4.

Tab.4 Cronbach's alpha values of risk factors in green building projects.

Risk factor group	Number of Questions	value
Economic sustainability	6	0.647
Social sustainability	5	0.675
Environmental sustainability	4	0.752
Management sustainability	4	0.622

As seen in Table 4, Cronbach's alpha value is 0.647 for economic sustainability, 0.675 for social sustainability,0.752 for environmental sustainability, and 0.622 for management sustainability. Since all Cronbach's alpha values are higher than 0.60, it can be concluded that all reliability coefficients are acceptable.

Based on the data obtained from experts' assessments, this paper ranks the probability, influence and risk criticality of risk factors from overall. Tab.5 is a ranking of all risk factors.

Tab.5 Risk factors affecting green building projects and their P,I and RC

Risk factors affecting green building projects	I		P		RC	
	Average	rank	Average	rank	Average	rank
1. economic sustainability						
Operational performance fails to meet the objectives of the project	3.4	9	3	3	10.2	3
Change of government support policy	4.3	1	2.1	15	9.03	6

Green building market demand forecast is not allowed	2.2	18	2.2	11	4.84	18
Increase in the cost of green building projects	2.9	13	2.6	8	7.54	10
Inflation	1.7	19	2	16	3.4	19
The cost of conducting a green building standard assessment becomes higher	2.9	13	2.2	11	6.38	14
2.Social sustainability						
Poor construction of design innovation	2.8	15	3.1	2	8.68	7
The public's satisfaction with the project is very low	4.1	3	3	3	12.3	2
Having negative impact on Society	4.2	2	1.6	18	6.72	12
Poor habitability	3	12	2.2	11	6.6	13
Construction accident	3.7	6	1.5	19	5.55	16
3.Environmental sustainability						
Insufficient on-site investigation resulted that not adjust measures to local conditions	2.7	16	2.3	10	6.21	15
Project evaluation results did not reach the expected level	4	4	1.7	17	6.8	11
Green building energy efficiency has not reached the expected level	3.7	6	2.2	11	8.14	9
Unstable performance during green building operation	3.7	6	2.7	7	9.99	4
4.Management sustainability						
Lack of experienced managers in the operational phase	3.8	5	3.7	1	14.06	1
Irrational responsibilities assignment matrix	3.1	11	2.8	6	8.68	7
Poor organization and coordination ability of managers	3.4	9	2.9	5	9.86	5
Labour disputes	2.3	17	2.4	9	5.52	17

According to the ranking results given in Table 5 the risk factor affecting green building projects have the greatest influence 2 risk factors is “Change of government support policy” and “Having negative impact on Society”. On the other hand, the risk factor that is most likely to occur is “Lack of experienced managers in the operational phase” and “Poor construction of design innovation”, and on the risk criticality index, it can be found that “Lack of experienced managers in the operational phase” and “The public's satisfaction with the project is very low ” is the most severe risk factors .

From this we can see that the green building project is in great need of government support, and the satisfaction of the people will have a certain impact on the development of the entire green building industry. At the same time, China's green building projects have certain deficiencies in innovation capabilities and technologies, such as poor energy-saving effects, high costs, and the lack of professional green building project management talents.

4. Conclusions

The green building project is a relatively new concept in developing countries such as China, Turkey and so on. Therefore, it is easy to encounter various risks in the construction process, which may cause the project to be delayed or completed unqualified or even impossible to complete. The Central Government of China and local governments are all making great efforts to develop green buildings and have issued many related policies to encourage the development of green buildings, such as the “Opinions on Accelerating the Promotion of Green Buildings in Shunde District, Shunde, Guangdong”

[21]was published in 2012, Hunan Province proposes that 30% of new houses in 2020 will be green buildings, etc. Therefore, it is particularly important to be familiar with potential risk factors and thus protect yourself from potential threats and negative consequences. In this study, the risk probability ,degree of influence and the risk criticality index of 19 risk factors, which were identified in the light of the literature review may affect green building projects were calculated based on the data collected from 10 Experienced experts via a questionnaire survey consisting of 25 questions. The survey results revealed that China's green building technology still needs a further step to better ensure that the next green building can operate better, and more green building project managers need to be trained and China need to create more green buildings that are more functional and satisfy the people who live in there.

References

[1] GB/T 50378-2006 ,Assessment standard for green building[S],Beijing: Ministry of Housing and Urban-Rural Development of the People's Republic of China,2006
[2] Yang Yi. Explaining architectural design and building energy efficiency[J]. Doors and windows,2013(02):359.(in Chinese)
[3] Wang Jing hui, Qin Xuan, Wan Xin. Risk Factor Identification and Risk Path Analysis of Green Building Projects [J]. Construction Technology,2012,41(21):30-34(in Chinese)
[4] Qin Xuan and Jing Lei. Assessment and Analysis of Life Cycle Risk Factors of Green Buildings: Based on Questionnaire Survey[J].China Civil Engineering Journal,2013,46(08):123-135.(in Chinese)
[5] Xianbo Zhao, Bon-Gang Hwang, Yan Gao. A fuzzy synthetic evaluation approach for risk assessment: a case of Singapore's green projects [J].Journal of Cleaner Production,2016:203-213.
[6] GB/T 50378-2014 ,Assessment standard for green building[S],Beijing: Ministry of Housing and Urban-Rural Development of the People's Republic of China,2014
[7] Zou, P. X. W., Zhang, G., & Wang, J. (2007). Understanding the key risks inconstruction projects in China[J]. International Journal of Project Management, 25,601–614.
[8] Liu, J., Zhao, X., & Yan, P. (2016). Risk paths in international construction projects: Case study from Chinese contractors[J]. Journal of Construction Engineering and Management, 142, 05016002.
[9] Qin Xuan and Jing Lei. Assessment and Analysis of Life Cycle Risk Factors of Green Buildings: Based on Questionnaire Survey[J].China Civil Engineering Journal,2013,46(08):123-135.(in Chinese)
[10] Roumboutsos, A., & Anagnostopoulos, K. P. . Public private partnership projects in Greece: Risk ranking and preferred risk allocation[J]. Construction Management and Economics, 26, 751–763.
[11] Al-Sabah, R., Menassa, C. C., & Hanna, A. . Evaluating impact of construction risks in the Arabian Gulf Region from perspective of multinational architecture, engineering and construction firms[J].
[12] Chuing Loo, S., Abdul-Rahman, H., & Wang, C. Managing external risks for inter national architectural, engineering, and construction (AEC) firms operating in gulf cooperation council (GCC) states[J]. Project Management Journal,44, 70–88.
[13] Chan, D. W. M., Chan, A. P. C., Lam, P. T. I., Yeung, J. F. Y., & Chan, J. H. L. Risk ranking and analysis in target cost contracts: Empirical evidence from the construction industry[J]. International Journal of Project Management, 29, 751–763.
[14] Qin, X., Y. Mo and L. Jing, Risk perceptions of the life-cycle of green buildings in China. Journal of Cleaner Production, 2016. 126: p. 148-158.
[15] Wan Xin, Qin Xuan. Risk identification and evaluation of green building projects based on empirical research[J]. Building Science, 2013, 29(02): 54-61.

[16] El-Sayegh, S. M., & Mansour, M. H. Risk assessment and allocation in highway construction projects in the UAE[J]. Journal of Management in Engineering, 31.
[17] Rebeiz, K. S. (2012). Public-private partnership risk factors in emerging countries: BOOT illustrative case study[J]. Journal of Management in Engineering, 28,421–428
[18] Field, A., Discovering Statistics Using SPSS[M]. Sage, London, 2005
[19] Pallant, J., SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS Version 12[M]. Open University Press, New York, 2005
[20] Bon-gang Hwang,Ming Shan,Nur Nadiah Binte Supa'at. Green commercial building projects in Singapore: Critical risk factors and mitigation measures[J]. Sustainable Cities and Society,2017,30.
[21] The people's Government of Foshan. Opinions on Accelerating the Promotion of Green Buildings in Shunde District, Shunde, Guangdong.2012.