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Application of Internet of Things and Cloud Computing for Evaluation of Key Performance Indicators for Indian Construction Projects through Consistent Fuzzy Preference Relations Approach

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Abstract: The construction industry is considered one of the world's most important industries. However, it is also one of the most conservative industries when adopting new processes or technologies. The internet of things (IoT) and cloud computing are the latest technologies that have piqued the interest of several industries. This research paper aimed to identify key performance indicators (KPI) of IoT and cloud computing for construction projects and then evaluate the identified KPI through a multi-criteria decision-making tool, namely consistent fuzzy preference relation (CFPR). After evaluation, the CFPR approach was relatively simple to use, faster to execute and more efficient than the conventional analytic hierarchy methods. The method also provided consistent solutions in the decision-making processes. A total of 109 KPI were evaluated using the CFPR approach. The result showed that the nature and willingness of the organisation were the most severe KPI for the application of the IoT and cloud computing for the construction project. The corrective and preventative mitigation measures of the top ten KPI have also been proposed in this study in order to smoothly implement future projects.

Keywords: Cloud computing, Consistence fuzzy preference relation (CFPR), Internet of things (IoT), Key performance indicators (KPI), Indian construction projects

INTRODUCTION

The internet of things (IoT) is a relatively new technology that has piqued the interest of several industries (Lin, Shih-Tong and Chung, 2011). Cloud computing is a process for furnishing on-demand network access to a shared reservoir of generally programmable computer resources. This shared pool of resources may be instantly delivered and released with minimal effort or communication with the service provider (Kumar and Samalia, 2016). In recent years, it has been widely documented that various aspects of the construction industry impede the adoption of information technology (IT) by the industry as a whole. This sector lags behind other sectors in IT adoption (Kumar and Samalia, 2016).

Modern technologies push the construction sector to incorporate them to improve performance. IoT and cloud computing are the two branches of IT that have piqued the building industry's interest. The evaluation of key performance

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indicators (KPI) is required for IoT and cloud computing implementation in the construction industry. KPI are now commonly used to monitor performance and drive change in the construction industry. The performance measurements define the construction projects' effectiveness and efficiency. The success of IoT and cloud computing applications for construction projects will be measured by evaluating the KPI, a quantitative value indicating how successfully essential objectives were achieved. To be considered a helpful management process, a performance measurement system must operate as a mechanism that allows for assessment, offers relevant information, discovers problems and judges against specified criteria (Jafarnejad et al., 2014).

For the application of the IoT and cloud computing in construction projects, there was a requirement to identify, explore and evaluate the KPI associated with it because KPI are the variables that determine and measure the success criteria. Other up-to-date industries like telecommunications, automotive, healthcare and logistics have already benefited from IoT and cloud computing. In the construction industry, a limited number of research on applications of IoT and cloud computing has been conducted. This includes the development of a secure and emergent transportation platform (Jianfeng et al., 2013), the identification of traffic state urban roads and dynamic optimisation of urban freight activities (Wang, 2015), infrastructure asset management (Ng et al., 2018; Anumba et al., 2021), safety management (Zhang et al., 2019; Anumba et al., 2021), waterway (Wang and Sun, 2020) and wastewater management (Edmondson et al., 2018; Misra et al., 2018; Manojkumar et al., 2022), real-time monitoring (Ko, Azambuja and Lee, 2016; Jeong et al., 2019; Li et al., 2018; Xu et al., 2018; Anumba et al., 2021), facility management (Naticchia, Corneli and Carbonari, 2020; Lee et al., 2019) and energy monitoring (Wei and Li, 2011; Kaushik et al., 2022; Martín-Garín et al., 2018; 2020). The IoT and cloud computing can potentially improve and increase the construction industry's efficiency, performance, safety, security and quality. To effectively implement IoT and cloud computing in the construction industry, decision-makers must be aware of the factors affecting them.

KPI are elements that reveal issues while effectively achieving a goal. Decision-makers with critical KPI can make better decisions and increase their chances of success. The evaluation of KPI using the multicriteria decision-making (MCDM) method will aid in selecting, classifying and ranking KPI and the general assessment in the complex decision-making process. For IoT and cloud computing applications, they will be required to identify, explore and evaluate the KPI so that they can contribute to decision-making in the construction industry. Some researchers tried to evaluate the KPI associated with the application of IoT and cloud computing using conventional MCDM methods like fuzzy technique for order of preference by similarity to ideal solution (TOPSIS) (Bajpai and Misra, 2020) and analytical hierarchy process (AHP) methods (Hemanth et al., 2017; Zhihong, 2020) for the construction industry. Compared with conventional MCDM methods, the CFPR approach is easy, simple, applicable, feasible, executed faster and more efficient. It also improves decision-making consistency and effectiveness in complex systems. Because construction projects are complex systems, the authors in this study used the CFPR approach, which no researcher has used in the past to analyse KPI associated with IoT and cloud computing in construction projects.

The article is divided into the following sections. The section headed "Literature Review" reviews significant publications in academia. The "Methodology and Conceptual Framework" section addresses the questionnaire survey and the steps for applying the CFPR approach. In the "Case Study and Analysis" section, the KPI were identified and evaluated using the CFPR approach, the MATLAB algorithm code, the rankings of each KPI and the corrective and preventative mitigation measures are presented. The "Discussion" section highlights the study's results, suggestions and potential applications of the CFPR approach. The "Conclusion and Future Extensions" section summarises the key findings of this study and presents further research directions. This study aims to implement the CFPR approach to analyse the KPI associated with the application of IoT and cloud computing in Indian construction projects. Corrective and preventative mitigation measures have been provided to ensure the smooth implementation of future projects and the findings of this study can be used as a guide for performing risk assessments in Indian construction projects and worldwide.

LITERATURE REVIEW

KPI are one of the variables that determine the success criteria for construction projects. Sibiya, Aigbavboa and Thwala (2015) defined the performance measurement on construction projects by identifying the KPI that would provide objective criteria for measuring the construction project's success. According to Haponava and Al-Jibouri (2012), measuring construction project performance by the KPI determines the probability of the construction project's success. Patel, Kikani and Jha (2016) applied the CFPR approach to determine and conduct risk and hazard assessment analyses for a metro rail construction project. This study computed risk impacts through fuzzy set theory. They observed that the proposed method can compare the risk hazard and the corresponding safety budget. According to Patel, Kikani and Jha (2016), the CFPR approach is simpler, faster to execute and provides consistency.

Sarkar, Raghavendra and Ruparelia (2015) identified the KPI for the use of building information modelling as a tool for facility management. Herrera-Viedma et al. (2004) introduced the CFPR approach to create paired decision matrices based on additive transitivity. They also recommended the application of the method through two preference relations, CFPR and multiplicative preference relation (MPR). This strategy was found to simplify the design and associated surveys. The consistency of the respondents' preferences was also preserved exceptionally in this strategy. In addition, there was no need to spend extra time resolving or investigating the consistency issue. A speedy and precise choice procedure could be attained, especially when analysing additional criteria/alternatives.

In general, the CFPR approach has been applied in a number of previous studies such as measuring the aggregative degree of risk for implementing a Radio Frequency Identification, a wireless system with a tag and reader digital campus system (Chang, Hsu and Wang, 2013), analysing the of policy instruments on new energy vehicle industry (Li et al., 2016), predicting the success of knowledge management implementation (Wang and Chang, 2007a), measuring user perceived service quality of information in construction projects (Wang and Liang, 2006), selecting merger strategy for financial organisations (Wang and Lin, 2008), partnership selection (Wang and Chen, 2007), merger strategy for commercial banks operating in new financial setting (Wang and Lin, 2009), assessing the quality of life among the Setiu Wetlands' people (Alias and Abdullah, 2017), assessment of student-centred cooperative e-learning (Chang and Chen, 2009), determining the main criteria that influence students in choosing mathematics programme (Tahir et al., 2012), evaluating e-learning material design (Chao and Chen, 2007), evaluation of nationwide enterprise-starting environment of Daqing City (Wang et al., 2020), evaluating personnel selection criteria (Ozdemir, GökhanNalbant and Basligil, 2017), comparing the criteria and efficacy of remote e-learning (Chao and Chen, 2009), forecasting the probability of successful knowledge management (Wang and Chang, 2007b), risk management in supply chain (Jafarnejad et al., 2014), trans-shipment hub port selection for shipping carriers (Wang and Yeo, 2019), selection of a smart phone (Chao, 2017) and assessing priority of the risk factors of metropolitan underground project (Lu, Lin and Tzeng, 2009).

According to the existing literature, adequate work has been done on decision-making. Still, no proper literature has been discovered for any study in the field of application of a decision-making tool like the CFPR approach, especially for construction projects. Patel, Kikani and Jha (2016) applied CFPR to assess the hazards of metro rail construction projects, Lu, Lin and Tzeng (2009) applied CFPR to identify the risks for metropolitan underground projects. For shipping carriers, the CFPR approach was used by Wang and Yeo (2019) for trans-shipment hub port selection. However, no researcher has attempted or explored the application of CFPR for the digitisation of the construction industry, particularly in the application of IoT and cloud computing. Furthermore, the application of decision-making tools to evaluate performance indicators of IoT and cloud computing is nascent. The present research aims to apply a decision-making tool like the CFPR approach to evaluate the KPI for the IoT and cloud computing applications for a construction project. The outcome obtained was regarding the impact or risk index of the identified factors. Based on the impact of the severity or risk index of the identified factors, suitable corrective and preventative measures to minimise the risk severity have been recommended.

METHODOLOGY AND CONCEPTUAL FRAMEWORK

Questionnaire Survey

A questionnaire was prepared to identify the severity of the impact of the identified factors on the application of IoT and cloud computing in construction projects. It was designed primarily based on previous literature and the authors' personal experience and interaction with project personnel like project managers, project engineers and site engineers. The questionnaire was circulated amongst 225 target respondents in Gujarat, India who consisted of assistant professors, assistant project engineers, chief engineers, senior and junior civil site engineers, senior and junior civil engineers, chief managing directors, directors, deputy managers (civil engineer), regional finance managers, surveyors, junior town planners, architects, planning assistants and engineers, production engineers and project managers.

The questionnaire survey sample size was computed using the following equations (Ali, Al-Sulaihi and Al-Gahtani, 2013; Tripathi and Jha, 2018; Sarkar and Singh, 2021; Sarkar and Singh, 2022):

$$n = \frac{n'}{\left(1 + \frac{n'}{N}\right)} \qquad \text{Eq. 1}$$

$$n' = \frac{p+q}{v^2} \qquad \text{Eq. 2}$$

where *n* is the sample size, *n*' is the initial sample size estimated size, *N* is the population size, *p* is the proportion of the characteristic being assessed in the population, *q* = 1– *p* and *v* is the sampling population standard error. The values of and were adjusted to 0.5 to acquire the most significant sample size possible. The standard deviation was set at 4% and the highest permitted value of the standard error is 10%. The total number of target respondents was 90. As a result, the population size, *N* = 225. The initial estimate of sample size was obtained by inserting these numbers into the equations:

$$n' = \frac{0.5+0.5}{0.04^2} = 156 \qquad \text{Eq. 3}$$

Therefore, the sample size was:

$$n = \frac{156}{\left(1+\frac{156}{225}\right)} = 92.30 \text{ say } 92 \text{ nos}$$

Out of a target size of 225 respondents, a total of 170 responses were received. The response rate was 75.55%, which was acceptable (Sarkar and Singh, 2021; Sarkar and Singh, 2022). Figure 1 displays the numbers and designations of responses involved in the different categories of construction industry professionals. The responses from 170 respondents were analysed through the CFPR approach. The average of all the respondents' experience was 15.37 years.

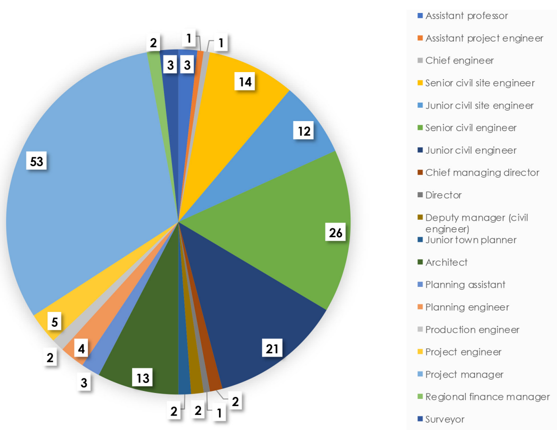

Figure 1. The responses involved the different categories of professionals in the construction industry

Methodology

The approach used in this study is primary data research. Data affecting and associated with various IoT and cloud computing implementation activities was obtained through a survey randomly conducted at multiple construction project sites in Gujarat, India.

Perfect consistency is difficult in practice, especially when assessing preferences over many options. It concentrates on avoiding inconsistencies in decision-making processes. Because it only takes $n - 1$ assessment from a set of n elements, this study used the reciprocal additive CFPR proposed by Chiclana et al. (2007). In multi-criteria problems, the parameters or criteria frequently have incongruous dimensions, which can cause evaluation issues. A fuzzy system is required to avoid these problems. The evaluation becomes simpler when fuzzy numbers are used through the CFPR approach for criteria analysis. CFPR approach is a straightforward, realistic modelling and compensatory method that consists of or restricts alternative solutions backed by hard cut-offs.

Step 1: Identification of key performance indicators

The primary objective of evaluating the performance of projects was to assist members and managers in developing the organisation's overall speed, traction and direction. Based on existing research, the characteristics of these KPI can be determined. Each KPI has unique characteristics. The variation in these characteristics affects the risk involved in carrying out the work and, as a result, causes problems for various construction companies. The existing studies have identified 109 KPI and their categories in five parts. However, each KPI has its own set of characteristics and thus carries its own set of risks. It is essential to compare all KPI based on expert opinion. Thus, identifying KPI is a critical first step in establishing a performance measurement system. When correctly specified and implemented, these KPI can play an essential role in providing information on the performance of construction companies. KPI are one of the elements that make up the project success criteria (Ali, Al-Sulaihi and Al-Gahtani, 2013).

Step 2: Responses of experts

A questionnaire survey was conducted to gather information from the study respondents. The questionnaire was created to collect the relative importance of various risk factors as roadblocks. The questionnaire was divided into five sections, each including a description of the numerous risks and the impact of those risks. The consequences of risks: "No Impact", "Mild Impact", "Moderate Impact", "Very High Impact" and "Severe Impact", were detailed. A CFPR approach was used to examine the indicated dangers. Finally, mitigation methods that were both corrective and preventative were suggested.

Step 3: Obtaining the pairwise comparison response from experts

Obtaining experts' responses to pairwise comparisons for each of the five risky trades creates a pairwise comparison matrix. There was a total of $n - 1$ input preferences $\{r_{12} + r_{23} + \ldots + r_{(n-1)(n)}\}$. Expert responses were in MPR. In a pairwise comparison of the two KPI being compared, a respondent was required to choose the following KPI based on its level of impact or risk of working. Following this comparison, the intensity of importance of the selected KPI is assigned. The input options of the attribute levels for comparison of the different parameters are based on a scale developed by Saaty (1980), depicted in Table 1.

Table 1. Attribute levels for comparison of the factors

Intensity of Impacts	Definition	Explanation
1	No impact	The impact is negligible
3	Mild impact	Obstacles are mildly affecting the implementation
5	Moderate impact	Obstacles are moderately affecting the implementation
7	Very high impact	Obstacles are very highly affecting the implementation
9	Severe impact	Obstacles are severely affecting the implementation
2,4,6,8	Intermediate values used to present compromise	Obstacles have intermediate values affecting the implementation

Step 4: Input data aggregation, forming initial decision matrix, complete altered decision matrix, the score, weight and rank of the criteria

The responses of the experts must be compiled. The geometric mean was used for aggregation, as shown in Equation 4.

$$r_{ij} \,.\, r_{jk} \,.\, r_{ki} = r_{ik} \,.\, r_{kj} \,.\, r_{ji} \qquad \text{Eq. 4}$$

There were n^2 items in the initial matrix. $R = [r_{ij}]$ denotes the starting matrix. Only replies for $n - 1$ item were obtained. Furthermore, all diagonal elements were 1. The following equation converts the MPR matrix to the fuzzy preference relation matrix. The fuzzy preference relation matrix was $Y = [y_{ij}]$ where $y_{ij}\ \varepsilon[0,1]$(Herrera-Viedma et al., 2004).

$$\left(y_{ij}\right) = \frac{1}{2}\left(1 + \log_9 y_{ij}\right) \qquad \text{Eq. 5}$$

where Y was a transformation function was examined since $y_{ij} \in (1/9, 9)$. A decision matrix consistency is determined by additive transitivity. After converting the MPR to the fuzzy preference relation (FPR), the following equations generated a complete CFPR matrix.

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}\ ,\ \forall\, i, j, k \qquad \text{Eq. 6}$$

$$r_{ij} + r_{jk} + r_{ki} = \frac{3}{2}, \forall\, i < j < k \qquad \text{Eq. 7}$$

The following expressions were equivalent for a reciprocal FPR, $R = [r_{ij}]$:

$$r_{i(i+1)} + r_{(i+1)(i+2)} + r_{(i+k-1)(i+k)} + r_{(j+k)i} \; \frac{k+1}{2}, \forall i, k \qquad \text{Eq. 8}$$

A consistent decision matrix represents each questionnaire response. A decision matrix with interval entries` (p – 1 p], p > 0, but not [0,1] should be transformed using a function that respects reciprocity and additive consistency. The transformation function was defined as follows:

$$f{:}[-p, +p] \to [0,1],\; f(a) = \frac{a+p}{1+2p} \qquad \text{Eq. 9}$$

The FPR matrices, $R = [r_{ij}]$ of pairwise comparisons, were generated and the criterion's weight was calculated. Each criterion's aggregation score was evaluated using the following formula:

$$u_i = \frac{1}{n_f} 1 \left(\sum_{j=1}^{n_f} r_{ij} \right) \qquad \text{Eq. 10}$$

The number of criteria to be calculated is n_f, r_{ij} was the value in the preference relation matrix R's ith row and jth column. Each criterion's weight (w) was expressed as:

$$w_i = \frac{U_i}{\sum_{i=1}^{nf} U_i} \qquad \text{Eq. 11}$$

CASE STUDY AND ANALYSIS

The IoT and cloud computing KPI for a construction project have been identified from the previous literature study and the authors' personal experience. The KPI were divided into five main factors: (1) organisation-related factors, (2) technology-related factors, (3) environmental-related factors, (4) data management and security-related factors and (5) innovation-related factors. The main factors were divided into various sub-factors. For example, organisation-related factors had 37 sub-factors, technology-related factors had 30 sub-factors, environmental-related factors had 15 sub-factors, data management and security-related factors had 22 sub-factors and innovation-related factors had five sub-factors. Table 2 describes the KPI affecting IoT and cloud computing applications for construction projects.

Table 2. KPI affecting the application of IoT and cloud computing for construction projects

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
Organisational-Related Factors		
1.	Top management support	Gutierrez, Boukram and Lumsden (2015); Olushola (2019); Lin, Shih-Tong and Chung (2011)
2.	Size of the organisation	Olushola (2019); Ahlmeyer and Chircu (2016); Gutierrez, Boukram and Lumsden (2015)
3.	Data management by organisation	Olushola (2019); Hakim, Singgih and Gunarta (2021)
4.	Organisational privacy and security	Olushola (2019)
5.	Capabilities for self-organisation	Olushola (2019)
6.	Organisational system complications	Xu, He and Li (2014)
7.	Coordination and communication problems	Tongsuksai, Mathrani and Taskin (2019)
8.	Specific IoT guidelines for organisation	Ahlmeyer and Chircu (2016)
9.	Executive management support	Ahlmeyer and Chircu (2016)
10.	Regulatory support of organisation	Olushola (2019); Ahlmeyer and Chircu (2016)
11.	Organisational service platform	Uslu, Okay and Dursun (2020)
12.	Social network of the organisation	Alhogail (2018)
13.	Organisational readiness	Chen, Zhang and Zhang (2010); Jedermann and Lang (2008)
14.	Government policy	Bandyopadhyay and Sen (2011); El-Abidi et al. (2019)
15.	Competitive pressure	Olushola (2019); Gutierrez, Boukram and Lumsden (2015)
16.	Organisational relationship	Coughlan et al. (2012)
17.	Organisational cloud readiness	Porrawatpreyakorn et al. (2019)
18.	Supportive organisational policy and procedure	Porrawatpreyakorn et al. (2019)
19.	Organisational appropriate plan and culture	Silverio-Fernández, Renukappa and Suresh (2021); Porrawatpreyakorn et al. (2019); Tongsuksai, Mathrani and Taskin (2019)
20.	Clear cloud usage policy	Porrawatpreyakorn et al. (2019)

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Table 2. *Continued*

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
21.	Good project management practices	El-Abidi et al. (2019); Gupta and Misra (2016)
22.	Trustworthiness of service providers	Tongsuksai, Mathrani and Taskin (2019)
23.	Leadership skills of the organisation	Silverio-Fernández, Renukappa and Suresh (2021)
24.	Increase customer retention	Gupta and Misra (2016)
25.	Increase ability and flexibility to meet user requirements	Gupta and Misra (2016)
26.	Legal compliance by the organisation	Suhanto et al. (2019)
27.	Financial incentives provided by the organisation	Al-Mascati and Al-Badi (2016)
28.	Proper business design and strategy	Ghosh, Edwards and Hosseini (2020); El-Abidi et al. (2019)
29.	Training and skill development policy	El-Abidi et al. (2019)
30.	Ability to adopt prevailing market conditions	Olushola (2019)
31.	Employee feedback policy	Baker, Murphy and Fisher (1997); Alkhlewi, Walters and Wills (2015)
32.	Business process re-engineering policy	Alkhlewi, Walters and Wills (2015)
33.	Socioeconomic status of the organisation	Tariq et al. (2017)
34.	The reputation of cloud service providers	Singh and Srivastava (2018)
35.	Customer satisfaction	Ghosh, Edwards and Hosseini (2020)
36.	Nature and willingness of the organisation	Oke et al. (2021)
37.	Effect of power and politics	Emam (2013)
Technology-Related Factors		
1.	Technological infrastructure	Chan, Chong and Zhou (2012); Whitmore, Agarwal and Xu (2015)
2.	Technology integration	Hsu and Yeh (2017)
3.	IT expertise	Palacios-Marqués, Soto-Acosta and Merigó (2015)
4.	Facility for data interoperability	Uslu, Okay and Dursun (2020)

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Table 2. *Continued*

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
5.	Affordability of selected technology	Luqman and van Belle (2017)
6.	Knowledge and acceptance of novel technologies	Aripin, Zawawi and Ismail (2019)
7.	Technology readiness	Olushola (2019); Ahlmeyer and Chircu (2016); Gutierrez, Boukram and Lumsden (2015)
8.	Use of technology resources	Hawash et al. (2021)
9.	Technology information security	Hawash et al. (2021)
10.	Scepticism of the technology	Luqman and van Belle (2017)
11.	Agility, flexibility, user friendly and cost-effectiveness of the technology	Porrawatpreyakorn et al. (2019); Distefano, Merlino and Puliafito (2013); Gupta and Misra (2016); Tongsuksai, Mathrani and Taskin (2019); Al-Qirim (2011)
12.	Scalability, reliability, customisability and compatibility of the technology	Olushola (2019); Ahlmeyer and Chircu (2016); Uslu, Okay and Dursun (2020); Li et al. (2016); Alhogail (2018); Porrawatpreyakorn et al. (2019); Gupta and Misra (2016); Al-Qirim (2011)
13.	Security and privacy of security systems	Tongsuksai, Mathrani and Taskin (2019)
14.	Cloud privacy and security	Al-Qirim (2011)
15.	Service provider support	Al-Mascati and Al-Badi (2016)
16.	Software development, testing and professional development	Tongsuksai, Mathrani and Taskin (2019)
17.	Monitoring and evaluation of the technology	Tongsuksai, Mathrani and Taskin (2019)
18.	Availability of systems and services for the applied technology	Oke et al. (2021); Tongsuksai, Mathrani and Taskin (2019)
19.	Risk-free performance of the technology	Tongsuksai, Mathrani and Taskin (2019)
20.	Service model of cloud computing	Yang and Liao (2017)
21.	Performance of cloud networking devices	Yang and Liao (2017)
22.	Portability in the technology used	Al-Qirim (2011)
23.	Efficiency and confidentiality of the technology	Lee et al. (2009)
24.	Inadequate power supply	Amade and Nwakanama (2021); Oke et al. (2021)
25.	High cost of devices	Ibrahim, Esa and Rahman (2021)

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Table 2. *Continued*

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
26.	Physical protection of devices	Babu (2021); Qing (2019)
27.	Regular maintenance	Ibrahim, Esa and Rahman (2021)
28.	Robust IoT and cloud computing platform	Hakim, Singgih and Gunarta (2021)
29.	Dependency on internet connectivity	Ibrahim, Esa and Rahman (2021); Bello et al. (2021)
30.	Costly data subscriptions	Babu (2021); Qing (2019)
Environmental-Related Factors		
1.	Impact of energy consumption	Uslu, Okay and Dursun (2020); Al-Qirim (2011)
2.	Peer and government support for environment conservation	Nair et al. (2020)
3.	Pollution of air created by vehicles and industries	Zhao et al. (2020)
4.	Monitoring indoor air quality index	Jo et al. (2020)
5.	Impact on environment due to disparity of sensor data quality	Teh, Kempa-Liehr and Wang (2020)
6.	Government policies pertaining to the application of IoT in the environment	Silverio-Fernández, Renukappa and Suresh (2021)
7.	Environment-friendly IoT applications	Nair et al. (2020)
8.	Availability of natural air, daylight and suitable temperature in the infrastructure facility	Jeyasheeli and Selva (2017)
9.	Environmental-friendly system	Nair et al. (2020)
10.	Environment related care for the community	Luqman and van Belle (2017)
11.	Impact of sustainability factors	Nair et al. (2020)
12.	Reduce carbon footprint significantly	Al-Qirim (2011)
13.	Environmental factors that can cause sensor breakdown	Amade and Nwakanama (2021)
14.	Natural disaster	Alam (2017)
15.	Impact of geo-diversity	Polyviou, Pouloudi and Rizou (2014)

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Table 2. *Continued*

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
Data Management and Security-Related Factors		
1.	Level of data security, privacy and management systems	Tongsuksai, Mathrani and Taskin (2019)
2.	Data architecture	Olushola (2019)
3.	System for retrying data from the deployed sensors	Chatterjee, Kar and Gupta (2018)
4.	System for checking the accuracy of sensor data	Chatterjee, Kar and Gupta (2018)
5.	System for modification of erroneous sensor data	Chatterjee, Kar and Gupta (2018)
6.	Data processing and exploration system	Terrada et al. (2018)
7.	Ubiquitous data exchange through wireless technologies	Olushola (2019)
8.	Embedded security systems	Olushola (2019)
9.	Data acquisition system	Ghosh, Edwards and Hosseini (2020)
10.	Data complexity	Ahlmeyer and Chircu (2016); Uslu, Okay and Dursun (2020); Li et al. (2016)
11.	Network protocol selection	Uslu, Okay and Dursun (2020)
12.	Type of data communication	Uslu, Okay and Dursun (2020)
13.	Data standardisation	Uslu, Okay and Dursun (2020)
14.	The disparity in sensor data quality	Banerjee and Seth (2017)
15.	Data authentication and integrity	Chen, Zhang and Zhang (2010); Gupta and Misra (2016)
16.	Data confidentially and auditability	Redmond et al. (2012); Tariq et al. (2017)
17.	Insecure or incomplete data deletion	Jiao et al. (2012)
18.	Data accessibility, backup and recovery	Chen, Zhang and Zhang (2010); Tongsuksai, Mathrani and Taskin (2019)
19.	Data accuracy and quality	Qing (2019); Al-Qirim (2011)
20.	Data storage facility	Gupta and Misra (2016)
21.	Cloud device security testing	Yang and Liao (2017)
22.	Cloud network performance testing	Yang and Liao (2017)

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Table 2. *Continued*

No.	KPI Affecting the Application of the IoT and Cloud Computing for Construction Projects	
	Description of KPI	**Sources**
Innovation-Related Factors		
1.	Discovery pertaining to the IoT technology	Zaslavsky and Jayaraman (2015)
2.	Innovation to create affordable and energy efficient devices	Qing (2019)
3.	Innovativeness of users	Tongsuksai, Mathrani and Taskin (2019)
4.	Innovative culture	Tongsuksai, Mathrani and Taskin (2019)
5.	Research, development and innovation of the technology	El-Abidi et al. (2019)

The average score and initial fuzzy preference ratios for each paired comparison were calculated. Equation 4 converts the original fuzzy preference ratios from an average score. The initial computed values of the criteria are shown in Table 3. The converted average scores are shown in the first row. Meanwhile, the initial fuzzy preference ratio is listed in the second row of Table 3. For each criterion, the corresponding denotation used in the decision matrix M is represented in the third row.

Table 3. Initial pairwise comparison score in the decision matrix (M)

	a_1/a_2	a_2/a_3	a_3/a_4	.	.	.	a_{106}/a_{107}	a_{107}/a_{108}	a_{108}/a_{109}
Fuzzy preference ratio (*R*)	0.9529	0.0629	0.9373	.	.	.	0.0549	0.0492	0.9698
Notation (r_{ij})	r_{12}	r_{23}	r_{34}	.	.	.	r_{106107}	r_{107108}	r_{108109}

M decision matrix was constructed as a starting point. The starting values of several fuzzy preference ratios in the decision matrix. The equation was used to calculate the values. All of the diagonal values were 0.5 and the r_{ij} values will be determined in the next stage.

Table 4. The initial decision matrix (M)

$X1$	$X1$	$X2$	$X3$	$X4$	.	.	.	.	.	$X107$	$X108$	$X109$
$X2$	0.5000	0.9529	r_{13}	r_{14}	.	.	.	.	.	r_{1107}	r_{1108}	r_{1109}
$X3$	r_{21}	0.5000	0.0629	.	.	.	.	.	.	r_{2107}	r_{2108}	r_{2109}
$X4$	r_{31}	r_{32}	0.5000	0.9373	.	.	.	.	.	r_{3107}	r_{3108}	r_{3109}
.	r_{41}	r_{42}	r_{43}	0.5000	.	.	.	.	.	.	.	.
.	.	.	.	.	0.5000	.	.	.	.	.	.	.
.	.	.	.	.	.	0.5000	.	.	.	.	.	.
.	.	.	.	.	.	.	0.5000	.	.	.	.	.
.	.	.	.	.	.	.	.	0.5000	.	.	.	.
$X106$	.	.	.	.	.	.	.	.	0.5000	0.0549	.	.
$X107$	.	.	.	.	.	.	.	.	.	0.5000	0.0492	.
$X108$	r_{1081}	r_{1082}	r_{1083}	.	.	.	.	.	.	r_{108107}	0.5000	0.9698
$X109$	r_{1091}	r_{1092}	r_{1093}	.	.	.	.	.	.	r_{109107}	r_{109108}	0.5000

MATLAB's functions comprise several lines of code that link one variable to another and each output is connected to a specific input. They are an essential aspect of every programming language. They can take many arguments as input and return multiple arguments as output. They work with the variables defined in their predefined workspace, called the local workspace. The data was normalised using a MATLAB algorithm to find the corresponding matrix's missing values. The developed algorithm was based on Equations 9, 10 and 11. The generated algorithm for finding the missing values of the matrix is presented in Figure 2. The same procedure was used to calculate all *r*-values. M, the complete decision matrix is shown in Table 5.

```
n=108;
D=zeros(n+1,n+1);
F=zeros(n+1,n+1);
F1=zeros(n+1,n+1);
for i=1:n+1
    D(i,i)=0.5;
end
tr=[0.952909743, 0.062999416, 0.937392591, 0.937392591, 0.08222974, 0.075914076,↙
0.943574562, 0.088725703, 0.946227245, 0.94089059, 0.07139151, 0.069768973, 0.062999416,↙
0.962929718, 0.062216077, 0.940504568, 0.072207137, 0.061046101, 0.939730554,↙
0.078419347, 0.957616796, 0.05680693, 0.946227245, 0.073847215, 0.0665582, 0.944335632,↙
0.095412565, 0.06616002, 0.937392591, 0.93063486, 0.07261605, 0.063392099, 0.052270704,↙
0.050036056, 0.044182105, 0.965020634, 0.963279541, 0.956178815, 0.950703976,↙
0.945472486, 0.05988211, 0.055664368, 0.952909743, 0.948849363, 0.061825416, 0.941275958,↙
0.063785461, 0.959756873, 0.042383204, 0.040954252, 0.96117249, 0.953275301, 0.942810937,↙
0.942428162, 0.94011789, 0.075914076, 0.95217686, 0.940504568, 0.061825416, 0.056044585,↙
0.963977577, 0.039888396, 0.960819411, 0.959045748, 0.053396311, 0.964325794,↙
0.957974876, 0.953640272, 0.949593023, 0.92901521, 0.073847215, 0.068559618, 0.952909743,↙
0.93383998, 0.074259088, 0.94011789, 0.939730554, 0.067756937, 0.05910941, 0.054905835,↙
0.968463359, 0.948849363, 0.061435425, 0.943574562, 0.05910941, 0.057955258, 0.946227245,↙
0.94011789, 0.06936514, 0.935820496, 0.068962023, 0.937783923, 0.073025699, 0.945850179,↙
0.935425769, 0.068157924, 0.051523381, 0.949593023, 0.062216077, 0.057955258,↙
0.057189063, 0.958332393, 0.081803198, 0.08052835, 0.955094334, 0.954731689, 0.054905835,↙
0.049296024, 0.969825997];
%display('Enter the super diagonal elements:');
for i=1:n
    D(i,i+1)=tr(i);
    %fprintf('\n');
end

for i=1:n
    k=1;
    k1=i+1;
    j=i+k;
    while(j<=n+1)
        %for p=j:n+1
        k2=1;
        d1=(k+1)/2;
        s=0;
        jj=j;
        while(jj>i)
            s=s+D(jj-1,jj);
            jj=jj-1;
        end
        D(j,k)=d1-s;
        k=k+1;
        j=i+k;
        k2=k2+1;
        %j=j+1;
    end
end


F=D;
k2=1;
for j=3:n+2
for i=j-1:n+1
    F(i,k2)=D(i,i-k2);
end
k2=k2+1;
end
for i=1:n-1
 for j=i+2:n+1
     F(i,j)=1-F(j,i);
 end
end
p=abs(min(min(F)));
for i=1:n+1
    for j=1:n+1
        F1(i,j)=(F(i,j)+p)/(1+2*p);
    end
end
F1
```

Figure 2. Algorithms for finding missing values of matrix

Table 5. The complete decision matrix

$X1$	$X1$	$X2$	$X3$	$X4$	.	.	.	.	.	$X53$	$X54$	$X55$
$X2$	0.5000	0.5347	0.5012	.	.	.	.	.	.	0.6875	0.6534	0.6189
$X3$	0.4652	0.5000	0.4665	.	.	.	.	.	.	0.6528	0.6187	0.5841
$X4$	0.4987	0.5334	0.5000	.	.	.	.	.	.	0.6863	0.6522	0.6176
.	.	.	.	0.5000	.	.	.	.	.	.	.	.
.	.	.	.	.	0.5000	.	.	.	.	.	.	.
.	.	.	.	.	.	0.5000	.	.	.	.	.	.
.	.	.	.	.	.	.	0.5000	.	.	.	.	.
.	.	.	.	.	.	.	.	0.5000	.	.	.	.
$X52$	.	.	.	.	.	.	.	.	0.5000	.	.	.
$X53$	0.3124	0.3471	0.3136	.	.	.	.	.	.	0.5000	0.4658	0.4313
$X54$	0.3465	0.3812	0.3477	.	.	.	.	.	.	0.5341	0.5000	0.4654
$X55$	0.3810	0.4158	0.3823	.	.	.	.	.	.	0.5686	0.5345	0.5000

Equations 9 and 10 were used to calculate each factor's aggregation score and weight. The whole decision matrix, M, is shown in Table 6 with the score, weight and rank of each criterion.

Table 6. Score, weight and rank of each criterion

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X	Organisational-Related Factors			
X1	Top management support	1.1362	0.0104	40
X2	Size of the organisation	1.0614	0.0097	51
X3	Data management by organisation	1.1336	0.0104	41
X4	Organisational privacy and security	1.0614	0.0097	52
X5	Capabilities for self-organisation	0.9892	0.0091	63
X6	Organisational system complications	1.0581	0.0097	53
X7	Coordination and communication problems	1.1282	0.0104	42
X8	Specific IoT guideline for organisation	1.0549	0.0097	54
X9	Organisational coordination problems	1.1228	0.0103	43
X10	Regulatory support of organisation	1.0491	0.0096	55
X11	Organisational service platform	0.9763	0.0090	64
X12	Social network of the organisation	1.0471	0.0096	56
X13	Organisational readiness	1.1182	0.0103	44

(*Continued on next page*)

Table 6. *Continued*

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X14	Government policy	1.1903	0.0109	33
X15	Competitive pressure	1.1139	0.0102	45
X16	Organisational relationship	1.1862	0.0109	34
X17	Organisational cloud readiness	1.1134	0.0102	46
X18	Supportive organisational policy and procedure	1.1841	0.0109	35
X19	Organisational appropriate plan and culture	1.2566	0.0115	22
X20	Clear cloud usage policy	1.1839	0.0109	36
X21	Good project management practices	1.2536	0.0115	23
X22	Trustworthiness of service providers	1.1780	0.0108	37
X23	Leadership skills of the organisation	1.2512	0.0115	24
X24	Increase customer retention	1.1775	0.0108	38
X25	Increase ability and flexibility to meet user requirements	1.2479	0.0114	25
X26	Legal compliance by the organisation	1.3194	0.0121	11
X27	Financial incentives provided by the organisation	1.2461	0.0114	26
X28	Proper business design and strategy	1.3129	0.0120	12
X29	Training and skill development policy	1.3845	0.0127	6
X30	Ability to adopt prevailing market conditions	1.3123	0.0120	13
X31	Employee feedback policy	1.2412	0.0114	27
X32	Business process re-engineering policy	1.3117	0.0120	14
X33	Socioeconomic status of the organisation	1.3838	0.0127	7
X34	The reputation of cloud service provider	1.4578	0.0134	4
X35	Customer satisfaction	1.5321	0.0141	2
X36	Nature and willingness of the organisation	1.6073	0.0147	1

(*Continued on next page*)

Table 6. *Continued*

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X37	Effect of power and politics	1.5306	0.0140	3
X	Technology-Related Factors			
X38	Technological infrastructure	1.4541	0.0133	5
X39	Technology integration	1.3787	0.0126	8
X40	IT expertise	1.3043	0.0120	15
X41	Facility for data interoperability	1.2307	0.0113	28
X42	Affordability of selected technology	1.3034	0.0120	16
X43	Knowledge and acceptance of novel technologies	1.3768	0.0126	9
X44	Technology readiness	1.3020	0.0119	17
X45	Use of technology resources	1.2279	0.0113	29
X46	Technology information security	1.3002	0.0119	18
X47	Scepticism in the technology	1.2274	0.0113	30
X48	Agility, flexibility, user friendly and cost-effectiveness of the technology	1.2994	0.0119	19
X49	Scalability, reliability, customisability and compatibility of the technology	1.2235	0.0112	32
X50	Security and privacy of security systems	1.2991	0.0119	20
X51	Cloud privacy and security	1.3749	0.0126	10
X52	Service provider support	1.2987	0.0119	21
X53	Software development, testing and professional development	1.2239	0.0112	31
X54	Monitoring and evaluation of the technology	1.1507	0.0106	39
X55	Availability of systems and services for the applied technology	1.0777	0.0099	47
X56	Risk-free performance of the technology	1.0050	0.0092	57
X57	Service model of cloud computing	1.0750	0.0099	48
X58	Performance of cloud networking devices	1.0004	0.0092	58

(*Continued on next page*)

Table 6. *Continued*

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X59	Portability in the technology used	0.9276	0.0085	65
X60	Efficiency and confidentiality of the technology	1.0000	0.0092	59
X61	Inadequate power supply	1.0733	0.0098	49
X62	High cost of devices	0.9967	0.0091	60
X63	Physical protection of devices	1.0726	0.0098	50
X64	Regular maintenance	0.9966	0.0091	61
X65	Robust IoT and cloud computing platform	0.9208	0.0084	66
X66	Dependency on internet connectivity	0.9945	0.0091	62
X67	Costly data subscriptions	0.9178	0.0084	67
X	Environmental-Related Factors			
X68	Impact of energy consumption	0.8422	0.0077	70
X69	Peer and government support for environment conservation	0.7673	0.0070	75
X70	Pollution of air created by vehicles and industries	0.6931	0.0064	82
X71	Monitoring indoor air quality index	0.6222	0.0057	96
X72	Impact on environment due to disparity of sensor data quality	0.6926	0.0064	83
X73	Government policies pertaining to the application of the IoT in the environment	0.7638	0.0070	76
X74	Environment-friendly IoT applications	0.6890	0.0063	84
X75	Availability of natural air, day light and suitable temperature in the infrastructure facility	0.6174	0.0057	97
X76	Environmentally friendly system	0.6877	0.0063	85
X77	Environment related care for community	0.6150	0.0056	98
X78	Impact of sustainability factors	0.5424	0.0050	108
X79	Reduce carbon footprint significantly	0.6138	0.0056	99
X80	Environmental factors that can cause sensor breakdown	0.6866	0.0063	86

(*Continued on next page*)

Table 6. *Continued*

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X81	Natural disaster	0.7601	0.0070	77
X82	Impact of geo-diversity	0.6827	0.0063	87
X	Data Management and Security-Related Factors			
X83	Level of data security, privacy and management systems	0.6086	0.0056	100
X84	Data architecture	0.6810	0.0062	88
X85	System for retrying data from the deployed sensors	0.6078	0.0056	101
X86	System for checking the accuracy of sensor data	0.6806	0.0062	89
X87	System for modification of erroneous sensor data	0.7536	0.0069	78
X88	Data processing and exploration system	0.6799	0.0062	90
X89	Ubiquitous data exchange through wireless technologies	0.6072	0.0056	102
X90	Embedded security systems	0.6783	0.0062	91
X91	Data acquisition system	0.6064	0.0056	103
X92	Data complexity	0.6775	0.0062	92
X93	Network protocol selection	0.6053	0.0056	104
X94	Type of data communication	0.6758	0.0062	93
X95	Data standardisation	0.6021	0.0055	105
X96	The disparity in sensor data quality	0.5302	0.0049	109
X97	Data authentication and integrity	0.6015	0.0055	106
X98	Data confidentially and auditability	0.6756	0.0062	94
X99	Insecure or incomplete data deletion	0.6014	0.0055	107
X100	Data accessibility, backup and recovery	0.6737	0.0062	95
X101	Data accuracy and quality	0.7466	0.0068	79
X102	Data storage facility	0.8198	0.0075	71
X103	Cloud device security testing	0.7441	0.0068	80

(*Continued on next page*)

Table 6. *Continued*

Code	Description of KPI	Aggregate Score of KPI	Priority Weights of KPI	Rank
X104	Cloud network performance testing	0.8131	0.0075	72
X	Innovation-Related Factors			
X105	Discovery pertaining to the IoT technology	0.8824	0.0081	68
X106	Innovation to create affordable and energy efficient devices	0.8073	0.0074	73
X107	Innovativeness of users	0.7322	0.0067	81
X108	Innovative culture	0.8057	0.0074	74
X109	Research, development and innovation of the technology	0.8801	0.0081	69

Based on the ranking of the KPI, it was found that "Nature and willingness of the organisation" was considered the KPI with the most severe risk affecting the implementation of IoT and cloud computing in the construction industry as it obtained the first rank. Other KPI that were found to have obtained Ranks 2, 3, 4, 5, 6, 7, 8, 9 and 10 were "Customer satisfaction", "Effect of power and politics", "The reputation of cloud service provider", "Technological infrastructure", "Training and skill development policy", "Socioeconomic status of the organisation", "Technology integration", "Knowledge and acceptance of novel technologies" and "Cloud privacy and security", respectively. The corrective and preventative mitigation measures for the KPI, which obtained Rank 1 to 10, are presented in Table 7.

Table 7**.** Recommended corrective and preventative mitigation measures for the first 10 ranked KPI

KPI Description	Rank	Corrective Mitigation Measures	Preventative Mitigation Measures
Nature and willingness of the organisation (X36)	1	The organisation must change its nature and willingness to adopt new technologies and methods	Awareness and proper strategy for the latest methods and technologies must be formulated
Customer satisfaction (X35)	2	Customer requirements need to be studied and analysed	Customer follow-up needs to be carried out after completing the work

(*Continued on next page*)

Table 7. *Continued*

KPI Description	Rank	Corrective Mitigation Measures	Preventative Mitigation Measures
Effect of power and politics (X37)	3	Specific guidelines are required in the organisation	A proper regulatory framework needs to be developed and implemented by the organisation
The reputation of cloud service providers (X34)	4	Cloud service providers need to maintain their reputation by satisfying their customers	The unique features need to be provided to the customers and the trust of the cloud service provider cannot be broken
Technological infrastructure (X38)	5	Proper infrastructure is required for the implementation of the latest technologies	A proper system must be developed and implemented to maintain the technological infrastructure
Training and skill development policy (X29)	6	The training and skill development programmes are conducted to implement the latest technologies	Regular training and skill development programmes should be conducted in the organisation
Socioeconomic status of the organisation (X33)	7	The socioeconomic status of the organisation needs to be maintained in the market	The socioeconomic scales need to be understood and maintained
Technology integration (X39)	8	Any complication in the system needs to be simplified	The system needs to be developed so that no future complication arises
Knowledge and acceptance of novel technologies (X43)	9	The organisation needs to be aware of the latest technologies	Proper research work needs to be carried out for the latest technologies
Cloud privacy and security (X51)	10	Any issue arising in cloud privacy and security needs to be addressed immediately	Proper cloud privacy and security systems must be installed to avoid these risks

DISCUSSION

The examination of parameters or criteria is required for the deployment of any new technology or performance measurement. The parameters or criteria in multi-criteria decision-making are typical of incongruent dimensions, which might generate assessment challenges. Various MCDM methodologies were applied to examine these challenges. It will help decision-makers determine which factors or criteria have the most significant impact on making important decisions.

A fuzzy system is necessary to prevent these difficulties. The CFPR approach has been used for criteria analysis since it is simple and best for complex systems. The CFPR approach has been found to simplify survey design and accompanying surveys. The respondents' decisions are likewise maintained consistently in the CFPR approach. Compared to the AHP technique, additional work is unnecessary to fix or evaluate the consistency issue due to additive transitivity. The CFPR method analyses *n* – 1 judgement in a preference matrix with n elements, whereas the AHP method considers $\frac{(n(n-1))}{2}$ judgements, reducing the pairwise comparison. For example, if the AHP method were employed for the 109 KPI analysed in this study, the consideration would be $\frac{(109(109-1))}{2} = 5,886$ judgements. If the CFPR approach is employed, however, only 109 – 1 = 108 judgements can be evaluated. Compared to the fuzzy TOPSIS, fuzzy AHP, fuzzy decision-making trial and evaluation laboratory (DEMATEL) and fuzzy multi-criteria optimization and compromise solution (VIKOR) methods, the CFPR approach looks the best since it is simple, faster, more reliable and more effective. It can easily maintain consistency (Patel, Kikani and Jha, 2016; Ranganath et al., 2022; Sarkar and Singh, 2021). The consistency ratio must be first determined for the other techniques. In addition, the CFPR approach gives consistent answers in complex decision-making procedures. Using the CFPR approach to solve the MCDM problem is viable based on its description and propositions.

The approach was used to do a risk analysis of the various attributes. "Nature and willingness of the organisation" ranked first using the CFPR approach and thus considered the most severe. Because the construction industry is so conservative, the organisation's nature and willingness to adopt IoT and cloud computing for construction projects was viewed as the most severe KPI affecting their implementation. They hesitated to accept the latest technology because they lacked faith in it. As a result, the construction industry lags behind other modern industries. Therefore, an education programme on the latest technologies is necessary. The nature of the construction industry and its willingness to accept new technology must change. The findings of this study are generally applicable and they may be utilised to apply IoT and cloud computing in construction projects in any location throughout the globe.

CONCLUSIONS AND FUTURE EXTENSIONS

The limitation of the study was that it was based solely on expert opinion. Analysis was done using the experts' responses. As a result, the quality of responses significantly influenced the outcome of the CFPR approach. Using the CFPR approach technique, a detailed study of the identified risks for all IoT and cloud computing KPI in the Construction industry indicated that all phases have risk potential. The aggregate score of the identified most severe KPI "Nature and willingness of the organisation" was 1.6073, with a priority weight of 0.0147. Other KPI that were found to have obtained Rank 2, 3, 4, 5, 6, 7, 8, 9 and 10 were "Customer satisfaction", "Effect of power and politics", "The reputation of cloud service provider", "Technological infrastructure", "Training and skill development policy", "Socioeconomic status of the organisation", "Technology integration", "Knowledge and acceptance of novel technologies" and "Cloud privacy and security", respectively. Any organisation's nature and willingness must be changed while adopting the IoT and cloud computing technologies. To achieve an organisation's nature, change and the organisation's willingness are needed while adopting novel technologies like the IoT and cloud computing.

For future studies, data for the project should be collected from people who are crucially involved in project implementation at many levels using the CFPR approach. Aside from that, the questionnaire should be answered by several people involved in the project implementation cycle responsible for ensuring that it will be completed on time despite many obstacles. As a result, the management may make more precise and decisive decisions, ensuring that risks are minimised or minimised to a minimum severity. Furthermore, the critical management team can take preventative steps for risk management, as corrective actions will have a significant economic impact and result in tragic incidents. For future work, the other multi-criteria decision-making techniques like fuzzy TOPSIS, fuzzy AHP, fuzzy DEMATEL and fuzzy VIKOR to evaluate KPI associated with IoT and cloud computing applications for construction projects.

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