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COST BENEFIT ANALYSIS (CBA) IN BUILDING INFORMATION MODELLING (BIM) APPLICATION IN GOVERNMENT HEALTHCARE FACILITIES PROJECTS IN MALAYSIA

Fazleemardyana Omar[1] and Mohd Ashraf Mohd Fateh[2]

[1]*Faculty of Architecture and Built Environment,*
INFRASTRUCTURE UNIVERSITY KUALA LUMPUR (IUKL)
[2]*School of Construction & Quantity Surveying, College of Build Environment (CBE),* UNIVERSITI TEKNOLOGI MARA (UITM)

Abstract

The healthcare industry in Malaysia is expected to grow to 127 billion ringgit by 2027. This vast investment definitely involved massive construction activities, which subsequently, require an advanced support system, to ensure the deliverable. Integration of CBA and BIM will further enhance the government construction project delivery. The level of BIM adoption in Malaysia's Construction industry is still low due to several obstacles; lack of knowledge of BIM, lack of data on the return on investment of BIM, and implementation cost and benefits. The objective of this paper was to identify the current approach of CBA toward BIM application in Government Healthcare Facilities in Malaysia. A mixed method with a nonprobability sampling technique was adopted. Where, 53 out of 90 respondents of the BIM expert population registered with the Public Works Department (PWD) BIM Centre have replied to the questionnaire. Meanwhile, five (5) semi-structured interview sessions were conducted. The findings have discovered that, awareness of the BIM application in the construction industry is important in this digital era. Nevertheless, the integration of CBA in BIM in Malaysia can be considered still low, compared to other countries such as Singapore and Australia. The integration of CBA in BIM adoption falls under level 3 of BIM Maturity.

Keywords: Building Information Modelling (BIM), Cost Benefit Analysis (CBA), Integration, Level of Adoption

[2] Corresponding author

INTRODUCTION

The construction industry is highly competitive, and all parties must be highly competitive and innovative to remain substantial progress and be successful (Chan et al., 2019). The healthcare industry in Malaysia particularly to be one of the most competitive industries today. The sector is expected to grow to 127 billion ringgit (US$30 billion) by 2027, fuelled by increasing demand for healthcare services from an ageing population, rising affluence, and increasing life expectancy (Medina, 2020). This large public investment in construction requires an advanced support system, to ensure the deliverable and provide a significant impact on national growth. One mostly used framework to support such crucial decisions in public projects and policies is Cost-Benefit Analysis (CBA) (Belay et al., 2016). The construction process for healthcare is more complex with emerging healthcare disruption, ageing infrastructure, and increasing patient demands for better services and facilities. Hence, Building Information Modelling (BIM), the process of creating and managing digital information about a built asset needs to be the standard for building projects, especially in the construction of complex healthcare projects (News Hub Asia, 2019).

Building Information Modelling (BIM) can be claimed as a procedural and technological shift in construction, it can provide betterment in project delivery. The Malaysian Government always provides full support for the implementation of digitalization of the construction sector through the policies outlined in the Construction Industry Transformation Plan (CITP) and via the 12th Malaysian Plan. and Construction 4.0 Strategic Plan (2021-2025). Government agencies such as the Public Works Department BIM unit and Construction Industry Development Board (CIDB) MyBIM Centre actively promote BIM and its benefits to the construction sector, through seminars and various other events. This effort has indirectly increased the level of awareness among players in the Construction industry regarding the benefits of BIM. The use of BIM alone without integrating it with other methods may not have a significant impact on project delivery (Mohd Fateh & Abdul Aziz, 2021). Belay et al. (2016) discovered, that in recent research, most scholars agreed, that it endeavours to embed some of the advanced modelling methods such as BIM and CBA to provide maximized benefits to the project delivery, particularly in cost-saving.

However, the level of adaptation of BIM in the construction sector depends on several barriers. Ullah, et al. (2019) discover among the top barriers facing either developed or developing countries in adopting BIM are (i) high initial cost, (ii) data ownership issues, (iii) interoperability between software programs and (iv) lack of standardized tools and protocols. From another perspective, the integration of BIM and CBA is no exception in facing the

barriers, as CBA is more cost-oriented, and most of the parties might consider cost information to be considered confidential.

LITERATURE REVIEW

Building Information Modelling (BIM) and Cost Benefit Analysis (CBA)

The emergence of BIM technology applied in the Architecture, Engineering, Construction, and Operation (AECO) industry acts as a cornerstone in speeding up the completion of the project. (BIM, 2009) as cited in Chen, et al. (2018) interpreted BIM as a multifaceted software data model by visualising an architectural design from virtual and augmented reality technologies through integration of capital and recapitalized installation into the design as a requirement from users. While Autodesk (2021) clarified BIM acts as an "intelligent 3D model-based process" tool for professional practitioners to efficiently plan, design, construct, and manage buildings and infrastructures primarily in the AEC industry. Though, obstacles and challenges may arise if the processes are not applied properly (Chan et al., 2019). Similarly, Liu et al. (2021) referred to BIM as a technological process of using a digital information model in a virtual environment to achieve construction management throughout the life cycle of construction facilities efficiently in the era of Integrated Digital Delivery (IDD). Likewise, Bryde et al. (2013) as cited in Ahmad Latiffi et al. (2016) defined BIM as an innovative way of approaching the design, construction operation, and maintenance of the building. While Brahim (2018) claimed BIM in her research as a methodology that improves the performance of work by allowing construction professionals to manage the construction process throughout the project lifecycles with the use of BIM technology. To summarize, Gerges et al. (2017) as cited in Darwish et al. (2020) concluded BIM can enhance the procedures and technologies in Architecture, Engineering, and Construction (AEC) industry.

Meanwhile, CBA was initially described as a systematic process for decision making by Benjamin Franklin (1772). It was largely invented by Jules Dupuit in the 1840s. The extensive real-world application of CBA started with the US Flood Control Act of 1936, which made CBA mandatory for flood control projects. In 1950, guidelines were published. After 1960, the use of CBA became mandatory in the US, Canada, and the UK for certain policies and projects (Koopmans, C., & Mouter, N.,2020). There are several definitions of CBA discovered by scholars. Cost-benefit analysis is a formal analysis of the impacts of a measure or program, designed to assess whether the advantages (benefits) of the measure or program are greater than its advantages (costs) (European Road Safety Observatory, 2018). However, David (1998) defined CBA as the process of using theory, data, and models to examine trades-off, products, and activities for assessing relevant objectives and an alternative solution to assist decision-

makers in choosing the most appropriate alternatives. From another perspective, Sean, C (2021) defined Cost Benefit Analysis (CBA), as a process or tool to support decision making in projects. CBA evaluates the cost versus the benefit of a project to determine project feasibility (how much the benefit outweighs the cost) as well as provide a decision-making metric when weighing up multiple options.

Level of BIM Adoption in Malaysia Construction

Implementation of BIM around the globe in recent decades forced many nations to transform their construction industry, particularly into digitalization. A report by the World Economic Forum (2018) has highlighted the importance of BIM as a centrepiece of the industry through the application of several technologies. The adoption of BIM throughout the whole construction lifecycle needs a collaborative and integrated platform and support from the industry players. BIM adoption in Malaysia is showing drastic improvement with 49% of industry players currently using BIM compared to 17% in 2016 (CIDB, 2020). This percentage, however, is still far behind the government's ambitions via Construction Industry Transformation Programme (CITP) 2019. Whereas to achieve 70% BIM adoption in private and public building projects above RM 10 million by January 2021 and 100% of all public building projects above RM 100 million (for PWD building projects) using BIM Level 2 by the 4th quarter in 2020. At glance, Malaysia's BIM adoption rate is still low at 49% compared to the UK's 69% in 2019 (BIM Report, CIDB 2020). The significant increase of 288.23% from 2016 to 2019 compared to only an increase of 127.78% for the UK, indicates a better future and prospect of BIM within the Malaysia Construction Industry.

Benefits of Integration CBA and BIM

Integration of CBA and BIM, provides the investors with both transparency of value and an understanding of the risks of complex infrastructure projects (Parker, J., & Parker, J. C., 2014). Furthermore, these tools can define relationships between objects and keep changes consistent and coordinated. So, as the design changes, so can the economic costs, benefits, and risks. BIM can show the economic business case for design alternatives while maintaining constraints such as building codes, design, or safety criteria, and local or community standards.

The integration of CBA and BIM is expected to enhance government construction project delivery. Belay et al. (2016) their research summarized, that, in managing a mega project which involved a longer span of several activities and challenges, one-methods cannot stand alone to make a sound critical decision. A combination of more than one method is necessary and thus needs a

holistic, integrated multi-criteria decision-making process. While Hamidi et al. (2014) stated in their research that conducting a cost-benefit analysis for demolition waste management is very crucial, to make sure that their practice brings profit to the companies.

The Significant of Integration of CBA and BIM in Government Healthcare Facilities Projects in Malaysia

The government's ongoing efforts to combat the outbreak of the Covid 19 pandemic which had been spread in early 2020 reflect the importance of health care for a country. The 12th RMK presented by Prime Minister Dato' Sri Ismail Sabri Yaakob, on 27th September 2021, has presented 9 main focuses, with the goal of "Keluarga Malaysia- Prosperous, Inclusive, Sustainable". Among others, the 5th Focus is on government efforts to increase the well-being of Malaysian families (Prime Minister's Office of Malaysia, 2019). Via this focus, the government has identified proactive measures to increase the preparedness of hospitals, to achieve a ratio of 2.06 hospital beds per 1,000 population by 2025, among others: -

i) The government will further develop new health facilities, in addition to the 12 hospitals that are being built nationwide and to be completed during the Twelfth Plan.
ii) Proposed construction of an Institute of Infectious Diseases which will be built in Bandar Enstek, Negeri Sembilan in 2022, and,
iii) Build and upgrade health clinics across the nation, to narrow the gap between urban and rural health facilities.

The government's concern as described above will certainly cost billions of ringgits in development. Therefore, it is significant and relevant for BIM and CBA to integrate, especially for government hospital projects, to ensure the delivery of the project will be more efficient and can be completed with time, quality, and fixed costs. Zhen (2021) stated that the introduction of BIM technology into the health facilities construction management stage, is important because of its visualisation, to minimise design defect, and make the engineering drawings more intuitive and easier to understand. It also can contribute to great cost savings, improve engineering quality and provide data support for future operation and maintenance activities.

BIM has transformed the way that buildings are designed and delivered, particularly when it comes to the construction of highly complex buildings such as healthcare facilities. Yet few healthcare organisations today are harnessing the potential operational improvements that can come from having BIM data at their fingertips. Much of the data needed for operations and maintenance (O&M)

processes already exists in the BIM models turned over following construction or could easily be included in these models with some advance planning. That healthcare lags other industries in its adoption of BIM for operations is particularly surprising since these complex buildings, with their critical missions, potentially stand to gain the most from using this data (Headley, 2016).

RESEARCH METHODOLOGY

A mixed methods approach had been selected to collect the data to obtain the desired information. The mixed methods were conducted through the dissemination of a set of survey forms among the sampling. The justification for the mixed method was to compliments each finding in each method used. While quantitative and qualitative methods each have their merits and demerits, adopting both can provide more representative findings. Survey and interview techniques will be done simultaneously, while the document review, which is also secondary data will be analyzed before the process of preparing questions for the survey and interview. This is to enable the data to be verified during survey activities and interviews. The full flow chart research process is presented in Figure 1.

These questionnaires had been distributed among the BIM Consultant population, who register with PWD BIM Unit, MyBIM CIDB, and also construction professionals who have direct exposure to Construction Projects with BIM Execution. The amount of sampling for this survey is set at 74 numbers of respondents. This is based on the 90 numbers of respondents (populations) registered via the MYBIM Resources Network List (MyBIM CIDB). No proper bodies are being established to provide appropriate registration and member monitoring as, what is being provided by other professionals such as architects, engineers, and quantity surveyors. The target sampling numbers are based on the sample size calculator provided by Raosoft. All research statements will be set according to the Likert Scale, from 1 to 5; whereas 1 (Strongly Disagree), 2 (Slightly Disagree), 3 (Slightly Agree), 4 (Somewhat Agree), and 5 (Strongly Agree). Findings are then transferred into Microsoft Excel software for further analysis. Where the median value was computed to determine the rank of each of the research statements, as outlined within the questionnaire survey. Mean implies average and it is the sum of a set of data divided by the amount of data. Where the mean value was derived from; the Value of Frequency (Σ vf) obtained from the Survey divided by the Maximum Value of Frequency (Σ max of vf). Σ vf = (1* n) + (2* n) + (3*n) + (4*n) + (4*n) ÷ Σ max of vf = (5*N). Whereas N is the Total Number of Respondents, and n was the Sub Value of respondents for each of the selected Likert scales.

Meanwhile, for the structured interview session, five (5) interview sessions were conducted. All the respondents have been specifically (based on their designation, number of BIM project involvement, and also the number of years in the construction) selected from the same sampling as the questionnaire session, who have completed the questionnaire.

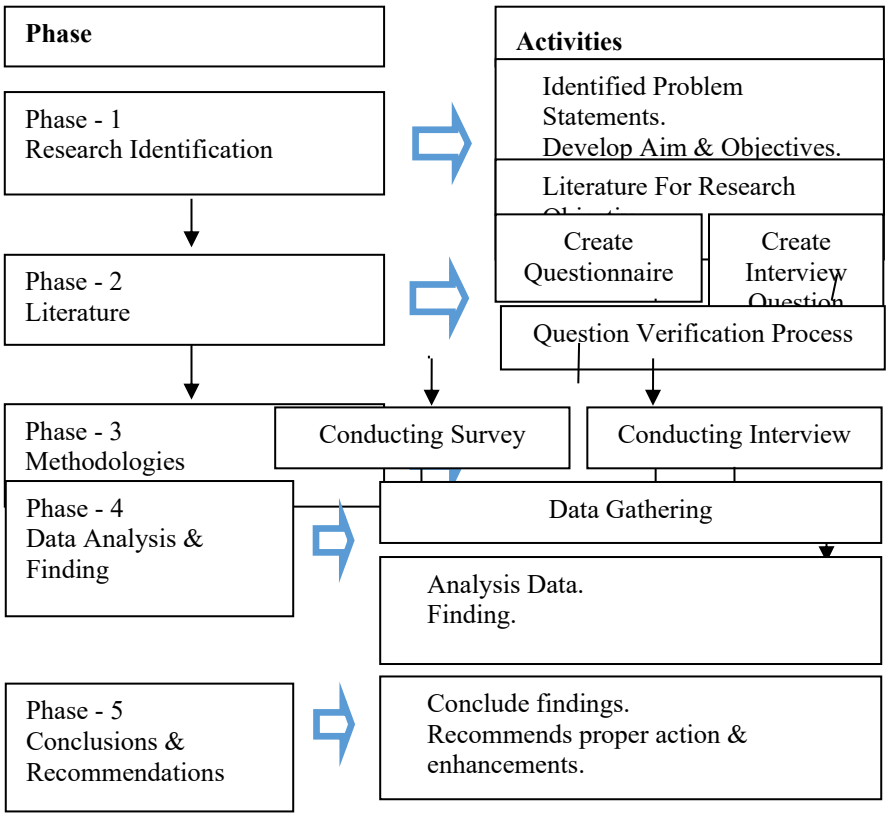

Figure 1: Research methodology flow chart

ANALYSIS AND DISCUSSION

Demography

Data on the demographic background were gained to gather personal information from the samples as stated in Table 1. The highest number of respondents answering the questionnaire experienced ranging from 0 to 5 years and 11-15 years, in the construction industry. However, the number of respondents who have more than 10 years of experience has been the largest sampling population within this analysis, which constituted 66%, this perhaps will translate to a more

sensible analysis. There are varieties of professions involved in responding to the questionnaire, and the quantity surveyor recorded the most frequent by almost 44%. This range perhaps provided more opinions from different professional perspectives.

Table 1: Respondents' background for the questionnaire survey

Profession	**No. Of projects handled using bim**	**Experience in the construction industry (years)**					**Frequency (By profession)**
		0-5	**6-10**	**11-15**	**16-20**	**>20**	
Architect	0-4	-	1	-	-	-	4
	5-8	-	-	-	1	-	
	>9	-	-	-	1	1	
Engineer	0-4	2	1	2	1	-	10
	5-8	-	1	-	-	-	
	>9	-	-	1	1	1	
BIM Manager/ Modular	0-4	1	-	1	-	-	8
	5-8	1	-	2	-	-	
	>9	-	-	-	1	2	
Quantity Surveyor	0-4	5	2	5	3	4	23
	5-8	-	-	1	1	-	
	>9	-	-	-	2	-	
Project Manager	0-4	-	-	-	-	-	2
	5-8	-	-	-	-	1	
	>9	-	-	-	-	1	
Others	0-4	4	-	-	-	1	6
	5-8	-	-	1	-	-	
	>9	-	-	-	-	-	
Frequency (Experience)		**13**	**5**	**13**	**11**	**11**	**53**

Demography Background for Semi-Structured Interview

All five (5) respondents are working in the construction industry for years and are involved with numerous BIM projects. Apart from that, the approached respondents come from different sectors in the construction industry three (3) respondents from government agencies Public Work Department (PWD), and two (2) respondents from the private sector with minimum academic qualification of bachelor's degree. Representatives with different backgrounds were chosen to

gain varied perspectives and understanding of the topic. A summary of respondents' demographic backgrounds is tabulated in Table 2.

Table 2: Respondents' background for the semi-structured interview session

Respondent	Education	Designation	Years of experience in construction	Number of BIM project involvement
R1	Bachelor (Hons) of Quantity Surveying, UTM Skudai	Quantity Surveying, Grade J41 at Public Work Department (PWD)	21 years	20 ~ 30
R2	Master of Construction Law, (LLM), University of Strathclyde, Scotland	Quantity Surveying, Grade J48 At Public Work Department (PWD)	18 years	5 ~ 10
R3	Bachelor (Hons) of Civil Engineering	Project Director Padang Rengas Construction (PRC) Sdn Bhd	37 years	Only 1
R4	Master of Construction Management, UTM Skudai.	Civil Engineer, Grade J44 at Public Work Department (PWD) BIM Unit	14 years	> 20
R5	Bachelor of Architecture, International Islamic University Malaysia (IIUM).	BIM Modular, at EV Dynamic Berhad	3.5 years	Only 1 Project

Current Approach of CBA To BIM Application in Malaysia Government Healthcare Facilities Projects

As tabulated in table 3, most of the respondents agreed that awareness of the BIM application in the construction industry is important in this digital era with a (4.623) median. Meanwhile, the respondents decided that the organization should not only rely on CBA for considering the project as there are several potential limitations, with a (4.132) median. In addition, several respondents have voiced their own opinion, regarding the current approach level of CBA toward BIM application in Malaysia the data tabulated in table 4.0.

However, the integration of CBA in BIM can be considered still low, compared to other countries such as Singapore and Australia. The integration of CBA in BIM adoption falls under level 3 of BIM Maturity. Where it involved full integration and 6D modelling. The fact is level of BIM maturity in Malaysia is still progressing from level 1 to level 2. This result seems to be parallel with the Malaysia BIM Report 2019 as conducted by CIDB. This can further be supported

by other findings concluded by Al-Ashmori, et al. (2020) discovered of BIM approach levels are still low compared to other developing countries.

Table 3: The current approach level of CBA towards BIM application in Malaysian government healthcare facilities projects.

No.	Research statements	Median	Rank
B01	Awareness of BIM applications in the construction industry is important in this digital era.	4.623	1
B04	BIM allows construction professionals to manage the construction process throughout the project lifecycles.	4.509	2
B02	BIM is an advanced tool to enhance the procedure and use of technology in the Architecture, Engineering, and Construction (AEC) industry.	4.472	3
B03	The performance of design, construction operation, and maintenance of the building improved by adopting BIM.	4.453	4
B11	Integration of CBA and BIM offers a baseline for comparing projects by determining which project's benefits are greater than its cost through the best practice of BIM application.	4.396	5
B10	Managing a megaproject needs more than one method, for instance, integration of CBA and BIM, in decision-making, as it is more complex to make a critical decision.	4.377	6
B07	CBA is better at minimizing the risk for the capacity and feasibility of a construction project.	4.358	7
B08	Cost-effective decisions through CBA maximize gains for the construction project.	4.321	8
B13	Integrating CBA and BIM in a complex project, especially in healthcare facilities is efficient and beneficial as it involves many specialities and is complex.	4.321	8
B05	BIM allows construction professionals to manage the construction process throughout the project lifecycles.	4.283	10
B06	It is important to conduct the CBA as it provides a clear view of project viability. to develop strategies for the implementation of the project.	4.208	11
B12	CBA and BIM offer the best approach to achieving the organizational goal while saving on overall construction project investment.	4.208	11
B14	BIM removes extra time consumption which normally leads to extra cost, thus increasing the effectiveness of complex project construction.	4.170	13

B09	The organization should not only rely on CBA for considering the project as there are several potential limitations.	4.132	14

Table 4: The additional opinion on the current approach level of CBA towards BIM application in Malaysian government healthcare facilities projects.

Respondent no.	Additional opinion
R09	Awareness of BIM applications in the construction industry is important in this digital era.
R13	BIM allows construction professionals to manage the construction process throughout the project lifecycles.
R39	BIM is an advanced tool to enhance the procedure and use of technology in the Architecture, Engineering, and Construction (AEC) industry.
R40	The performance of design, construction operation, and maintenance of the building improved by adopting BIM.

All of the respondents have a piece of knowledge and a clear understanding of BIM software applications in the construction industry. According to table 5, generally, all of the respondents shared a similar understanding of BIM as a process, model, and system that integrates all construction disciplines in one program, and effectively assists the smoothness of the project life cycle. According to R3 and R4, BIM is a 3D modelling with parametric information and helps in the construction project's execution in a program. While the majority of the respondents clearly understand the CBA approach toward BIM application by mentioning it as cost, cash flow forecast, and decision making from the project's investment. Besides, R4 also added that the government adopts Creativity Index (C.I) to determine CBA as it is a vital approach to reducing potential additional costs since there is an exact return on investment in terms of monetary value. However, R1 admitted that he is not familiar with CBA, since PWD government agencies obtained a project using the exact budget from the end-user.

Table 5: Respondents' responses current approach level of Cost Benefit Analysis (CBA) towards Building Information Modelling (BIM) applications in Malaysia government healthcare facilities projects.

Respondent	Can you briefly describe your understanding of BIM and CBA?
R1	"*BIM has been implemented at PWD since 2010, in my understanding, BIM is not purely referring to design. It refers to a process in construction project execution, and it involves modelling, CPM, and costing. It supposedly involved all different disciplines architects, engineers, and quantity surveyors. Those processes need to have people software. I'm really not sure about CBA, normally PWD government agencies just procured a project using the exact budget from the end-user".*
R2	*"BIM has what in my understanding and experience, BIM is a tool industry to assist product effective construction products, particularly in design. It helps to provide more efficient design and helps to reduce changes in design during construction. Where clashing was already made earlier and designed to be integrated into the model. While CBA is a tool related to cost, which provided a better decision to the government toward the deliverable of the project and its operation and maintenance".*
R3	*"For BIM as far as I understand, is Modeling for a project, more than making sure all items are done in the program. CBA to me determines from that we have what sort of cost, the pricing, the return on investment, and cash flow forecast".*
R4	*"BIM is a process of developing a 3D model with information and parametric, and it helps in construction project execution, including facilities management. It can also be considered as an approach, "rubbish in rubbish out". While CBA is some sort of study for decision making from any project investment. In government, CBA is meant to reduce potential additional costs since there is exactly return on investment in terms of monetary value, yet the government has Creativity Index (C.I) to determine Cost-Benefit Analysis (CBA)".*
R5	*"BIM is a system which integrates all construction disciplines, during construction activities and the project life cycle as a whole, to ease collaboration and it is a new thing".*

CONCLUSION

In conclusion, most of the respondents are understanding and aware of the BIM tools in the construction industries, contradictory, few respondents were aware of CBA. Furthermore, there is no denying that the current approach of BIM within the Malaysian construction industry was improving. However, the current approach between CBA into BIM application via Malaysia Government Project can be considered low, if compared to other countries such as Singapore and Australia. The integration of CBA in BIM adoption falls under level 3 of BIM Maturity. Where it involved full integration and 6D modelling. The fact is level of BIM maturity in Malaysia is still progressing from level 1 to level 2. There are multiple Critical Success Factors (CSFs) that influence this condition, and it involved the involvement of several stakeholders, and it requires policies, guidelines, finance, human capital, and technologies.

Since the CBA and BIM are the most important tools in the construction and its deliverables. It hopes that the government, via its technical agencies, properly and strictly enforced their current policies, to be followed by all the construction industry players. In addition, more training should be provided, to equip our construction industry professionals with the latest technology regarding CBA and BIM. Since the number of current seats for training available within our industry remains insufficient.

Industry players especially the private sector, contractors, consultants, and developers should have a high awareness of implementing CBA and BIM in Construction. They should not see the initial cost (direct cost) as a burden, but instead see the savings in indirect costs on the cost of operation and maintenance of a building and facilities, as an opportunity.

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