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Critical Government Strategies for Enhancing Building Information Modeling Implementation in Indonesia

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Abstract: Building information modeling (BIM) enables substantial improvement in the architect, engineering, and construction (AEC) industry. To enhance BIM implementation, policymakers should develop appropriate strategies addressing local AEC industry needs. However, prior works that have explored government strategies to enhance BIM implementation in Indonesia are scarce. Therefore, this study aimed to investigate the critical government strategies to enhance BIM implementation in Indonesia. A systematic literature review and semi-structured interviews with AEC professionals yielded 12 potential government strategies. The data were analyzed using mean score ranking, normalization, overlap, agreement, and correlation analyses. The findings illustrate that six strategies are critical for enhancing BIM implementation in Indonesia. Two of the six strategies overlapped between all main construction project stakeholders (i.e., consultants, contractors, and clients): (1) develop programs to integrate BIM into education curricula and academia, and (2) develop BIM implementation guidelines. These two strategies were highly correlated, and all project stakeholders had consistent views on their criticality for enhancing BIM implementation in Indonesia. The findings benefit policymakers by highlighting specific strategies that should take place to enhance BIM implementation in Indonesia.

Keywords: BIM; government strategies; government initiatives; Indonesia

Citation: Rani, H.A.; Al-Mohammad, M.S.; Rajabi, M.S.; Rahman, R.A. Critical Government Strategies for Enhancing Building Information Modeling Implementation in Indonesia. *Infrastructures* **2023**, *8*, 57. https://doi.org/10.3390/infrastructures8030057

Academic Editor: Linh Truong-Hong

Received: 21 January 2023
Revised: 3 March 2023
Accepted: 9 March 2023
Published: 15 March 2023

1. Introduction

Building information modeling (BIM) has enabled substantial improvement in the architectural, engineering, and construction (AEC) industry [1]. BIM promotes collaboration among project participants through data digitalization. With its digitalized data, BIM improves the interoperability between different project phases compared to the 2D paper format [2]. As evidenced by prior works, BIM implementation has eliminated unbudgeted change by 40%, improved cost estimation accuracy by 3%, saved contract value by 10%, and reduced project duration by 7% [3]. Thus, many believe that BIM is an optimal solution to addressing persisting challenges in the AEC industry [4–6]. Accordingly, the benefits of BIM have led to a surge in BIM use. Many governments have grasped opportunities with bold initiatives and strategies to enhance BIM implementation locally, including mandating BIM and developing BIM standards and guidelines [7]. This is mirrored in many developed economies, such as the UK and the USA, which have topped the BIM implementation rates [7,8]. However, the pace of BIM implementation in other countries has barely evolved [9].

One of the substantial steps in enhancing BIM implementation is identifying the factors that affect it and the corresponding strategies to address them. Prior works exploring strategies to enhance BIM implementation are prolific and cover different parts of the world.

The government-led strategies have gained value, evidenced by the increased number of BIM adopters [7]. However, countries with different geographical locations vary in economic development and conditions [10], causing significant gaps in BIM implementation levels [11]. BIM implementation highly depends on business culture and the AEC market environment [12]. Furthermore, BIM implementation is also subject to the perceptions of adopters [13]. For example, although there is a common perception of the positive impact of BIM on project performance, lowered project costs and shortened duration were not as positively perceived in China [14]. BIM implementation has a context-sensitive nature that causes regional differences in BIM movements [9]. Therefore, there is a need for regional-specific strategies that address the local industry gaps in BIM implementation.

Countries seek ways to increase economic growth and maintain sustainable development [9]. The construction sector in Indonesia is a growth driver, registering an annual growth of 4.83% in 2021. Investment in the construction sector, including dams, public roads, toll roads, and bridges, contributed to 1.28% of the overall economic growth [15]. These developments have propped up the country's competitiveness. However, like other industries, the Indonesian AEC industry took a significant hit from the COVID-19 pandemic, with several construction projects put on hold due to limited funds. The output of the AEC industry declined by 2% in 2020 due to social restriction policies [16]. With its impacted economy, Indonesia went from an upper-middle income to a lower-middle income in 2020 [10]. To ensure the continuation of construction projects and economic development, innovations in design and construction approaches, such as BIM, are needed. BIM has immense potential to deliver construction projects at a lower cost and shorter duration [3]. As resources are limited, effective strategies for enhancing BIM implementation that address the needs of local AEC professionals and environments should be developed [17]. The government is encouraged to commit resources to implement high-priority strategies to avoid straining resources and BIM implementation failure.

A review of existing works on BIM implementation suggests that several works have explored BIM implementation in different contexts. However, works investigating government strategies in the Indonesian context are scarce. Therefore, this study aimed to: (1) investigate critical government strategies to enhance BIM implementation in Indonesia, (2) identify overlapping critical government strategies between different project stakeholders, and (3) compare agreements among project stakeholders on these critical government strategies. A systematic literature review (SLR) and semi-structured interviews with AEC professionals were conducted to establish a list of potential government strategies for enhancing BIM implementation. The list was then disseminated to AEC professionals in Indonesia as a questionnaire survey. Mean score ranking, standard deviation, normalization, overlap, and inferential analyses were used to analyze the data. This study deepened the understanding of the critical government strategies for enhancing BIM implementation in Indonesia. The findings will help the government and policymakers allocate resources and address the local need to enhance BIM implementation in Indonesia.

2. Literature Review

2.1. Building Information Modeling Implementation: Global Context

The concept of BIM was initiated in the 1970s, and its implementation has piqued countries' attention in recent years. Return on investment (ROI) from BIM has been identified as a major driver of its implementation. To measure BIM benefits, some suggest using the key performance indicator (KPI) as a common term in construction projects [3]. According to [18], 84% of respondents indicated that BIM reduced project costs, and 84% reported that BIM facilitated the timely completion of projects. Ref. [19] found that using BIM achieved six months of savings schedule and a USD 9 million reduction in the overall project cost. Elsewhere, the number of requests for information decreased by at least 40% [20]. Thus, several countries and international bodies are attempting to drive the digital transformation of the AEC industry toward BIM. For example, BuildingSMART developed the Industry Foundation Class (IFC) for exchanging model data [21]. The IFC helps reference or archive model content and is an essential source for analyzing different disciplines. At a country level, the USA developed several BIM implementation guidelines and standards, such as the National BIM Standard (NBIMS-US), the BIM Guide Series 01 to 08, and the New York City (NYC) BIM Guidelines, and mandated the use of BIM in 2007 [22]. The UK government mandated BIM Level 2 in public projects in 2016 and established several initiatives to support BIM implementation (e.g., Government Construction Strategy 2011–2016 and 2016–2020) [23]. These initiatives helped increase the implementation rate to 73% in 2020 [8]. BIM was mandated in Germany in 2017 for projects worth over EURO 100 million [22]. Singapore established the National BIM Steering Committee to execute a roadmap and established guidelines to support BIM implementation. Other initiatives include initiating BIM-based pilot projects in 2011, mandating the submission of all plans in building projects with a gross floor area above 5000 m^2 in BIM format, and providing funds for BIM training [24]. Led by the Construction Industry Development Board (CIDB) and the Public Work Department, Malaysia established the BIM Technical Committee, the BIM Standard Manual and Guidelines, and the Construction Industry Transformation Programme (CITP) (2016–2020) [25]. Singapore and Malaysia recorded an implementation rate of 50% and 49% in 2018 and 2019. Hong Kong mandated BIM use in all public projects and reached an implementation rate of 75% [7]. In contrast, the BIM implementation rate is less than 30% in the Middle East and is relatively low in Africa due to the lack of strategies and initiatives for enhancing BIM implementation [26].

2.2. Building Information Modeling Implementation in Indonesia

Prior works tied to BIM in Indonesia have covered different angles, including case studies on BIM use, barriers to BIM implementation, and BIM readiness. For example, Ref. [27] employed BIM with Revit software and the critical path method for project planning. Ref. [28] used a 3D Laser scanner to build a 3D BIM model for a heritage building in Malang. The model was of great value in information documentation and displaying 2D and 3D information with a mobile data reviewer. Ref. [29] established a web BIM-based information system for enhancing the maintenance performance of landscape and housekeeping components. The established website could improve the comfort of landscape and housekeeping components. The work in Ref. [30] used the building structure in Bali for surveying and mapping sustainable development and managing land and facilities information. BIM has also been used in asset management. For example, Ref. [31] developed a 3D BIM model with rich data with the help of laser scanners and BIM software. The model has been valuable for visualizing the buildings and assets of the local government.

The work in Ref. [32] compared bridge design between the conventional approach and BIM. The findings revealed that using BIM eliminated design clashes and improved the safety of bridge structures. Ref. [33] employed BIM for analyzing slope stability through 3D drawing. The model was of great value for landslide mitigation. BIM, alongside a laser scanner, was used for simulating fire disaster evacuation [34]. Ref. [35] explored the possibility of integrating CAD with BIM. The work developed a scheme for using CAD data in BIM and determined the barriers during data exchange from CAD to Revit.

Several works have also explored the barriers to BIM implementation in the AEC industry in Indonesia. The cost of BIM implementation is a notable barrier to BIM implementation in Indonesia [36–40]. This barrier includes software and hardware price and fees for continuous maintenance and professional training. Thus, BIM is perceived as costly because it has high financial implications for project stakeholders. AEC organizations are reluctant to implement BIM as BIM software, proper infrastructure, and in-house personnel are out of reach [36,37]. At the individual level, prior works have found a lack of BIM awareness and knowledge among AEC professionals [38–42]. Professionals unaware of BIM and its benefits are most likely to reject the idea of BIM implementation and thus do not realize how BIM can improve construction practices. Consequently, they are unwilling to shift to a new workflow and insist on using traditional approaches. Ref. [40] revealed that contracts for BIM projects are still absent. Other works have concluded that the demand for

BIM from clients is insufficient to motivate and spread BIM implementation at the industry level [36,37,40].

The assessment of BIM readiness has also attracted scholars' attention. Ref. [43] explored the competency level of Revit usage among graduate students in a design and building information department. The study concluded that the competency level of the graduates could meet the needs of the AEC industry in Indonesia. The work in Ref. [44] evaluated BIM readiness among AEC companies in Indonesia. The findings showed that AEC companies are at a high readiness level in terms of coordinating between BIM and CAD, process redesign, implementation planning, and new role empowerment. At the same time, perceived benefits and risk management are at a low readiness level.

Ref. [45] investigated BIM implementation levels among contractors who already implemented BIM using a BIM Implementation Index (BIMII). The BIMII produced a 'quite achieved' score (67.47%), indicating a promising future in terms of BIM usage. The work in Ref. [46] investigated the issues tied to model ownership and intellectual property rights and proposed boundaries in BIM model usage between stakeholders.

2.3. Government Strategies for Enhancing Building Information Modeling Implementation

The role of the government in enhancing BIM implementation has been highlighted in several works. As a regulator and standard setter, the government can set the conditions for the AEC industry to change towards BIM [47]. Therefore, the government can greatly support industry players in BIM implementation [48]. The literature has highlighted several government strategies to enhance BIM implementation in local contexts. For example, improving BIM competencies and developing a digital transformation strategy are key to enhancing BIM implementation in the UK and Iran [1,49]. BIM-competent graduates can reduce outsourcing for BIM experts and overcome the challenge of the unavailability of BIM personnel. Furthermore, a clear transformation strategy helps establish organizational culture and new workflows and practices. Refs. [50,51] found that providing financial aid and incentives can reduce the financial burden on stakeholders and encourage BIM implementation in the USA and China. In addition to financial aid, Refs. [52,53] found that the Chinese government needs to develop a digital transformation strategy and standards to implement BIM, foster market demand for BIM, and mandate BIM in the AEC industry; the government can foster market demand for BIM by mandating its use across the industry. Early BIM mandate has proven sound for increasing BIM implementation. Conversely, Ref. [54] demonstrated that the key solution to promoting BIM implementation in the Finnish AEC industry was to develop implementation guidelines and initiate pilot projects to realize BIM benefits. Refs. [55,56] shared common findings that Netherlands and Italy should develop programs for equipping employees with BIM skills. However, unlike the Netherlands, Italy should further commit resources and efforts to engage employees in BIM projects and integrate BIM into the academic and education curricula. Integrating BIM into education curricula can fill the gap between industry and academia and generate BIM-skilled graduates. Previous works in other countries, including Malaysia and South Africa, have demonstrated a need to increase BIM awareness and understanding as a prerequisite to BIM implementation [57–59]. These strategies are critical to ensuring that stakeholders conceptualize BIM and its benefits. Governments can organize conferences, workshops, and awareness programs about BIM concepts and applications. Furthermore, BIM implementation involves a significant process change. Therefore, it has a great impact on the relationships between project parties. In Nigeria, legal and contractual frameworks clearly defining the relationships and responsibilities in BIM projects are necessary [60,61]. The government should be present to change the contracts in which BIM is used for delivering projects [62]. Furthermore, in contrast to previous works, the government in Nigeria should establish BIM institutes to train fresh graduates for successful BIM implementation [63].

The above review suggests that countries are struggling differently with BIM implementation. Moreover, due to the different levels of development of BIM, the strategies for enhancing BIM implementation vary from country to country. Therefore, to implement BIM effectively, country-specific strategies considering the local context, including Indonesia, are necessary.

2.4. Positioning This Study

The above review suggests that initiatives and strategies have helped disseminate knowledge on BIM and increase BIM implementation rates in several countries. Therefore, to enhance BIM implementation in the AEC industry in Indonesia, effective strategies for enhancing BIM implementation are necessary. However, prior works in Indonesia have focused on BIM use, readiness, and barriers to implementation. In other words, the focus on investigating government strategies to enhance BIM implementation in Indonesia is still lacking. Neglecting these strategies would strain resources and lead to BIM implementation failure. Therefore, exploring strategies to enhance BIM implementation in Indonesia is essential. This study fills this gap by identifying the government strategies that are critical for enhancing BIM implementation in the AEC industry in Indonesia.

3. Methodology

3.1. Survey Development

This study adopted a questionnaire survey to gather quantitative data on the government strategies for enhancing BIM implementation in Indonesia. A survey is an appropriate technique for capturing a wide range of responses from professionals in the AEC industry [63]. It is a common approach in construction management research to solicit professionals' opinions on a specific topic [49,50,58].

Initially, an SLR was conducted to identify potential government strategies in the literature. The review process began with searching the Scopus database for relevant articles using the "title/abstract/keyword" features. The Scopus database was selected for the search process because: (1) it is a commonly used database for SLR in the construction management research domain; (2) it includes more recent journals compared to other digital sources; and (3) it is one of the two popular databases that index construction management publications [64]. The search strings used to identify the initial articles included 'BIM' OR 'building information modelling' OR 'building information modeling' OR 'building information model' AND organization* OR organisation* OR firm* OR compan* AND 'construction industry' OR 'AEC' AND implement* OR adopt*. Several works have explored the role of the government and public clients in enhancing BIM implementation. Moreover, some works have analyzed the strategies and initiatives that governments can adopt to enhance BIM implementation. However, they did not explicitly mention any synonyms related to government in their title or abstract. Including 'government' or 'public client' in the search strings would miss some prior works relevant to the study's objectives. Therefore, this study did not include any search terms related to government. According to [65], most works in the BIM domain have been published after 2011. Hence, the timeframe for the study was between 2011 to 2022. The identified articles were screened using the inclusion and exclusion criteria. The inclusion criteria included English-written materials, works specifically focused on BIM implementation, literature included only in the Scopus database, and peer-reviewed journal articles. The exclusion criteria included non-English materials, works focused on generic terms (e.g., construction industry 4.0) or unrelated to BIM, literature out of the Scopus database, and conference proceedings due to their low quality. The search yielded 217 articles. A visual examination of the title and abstract was then performed to filter out articles that did not satisfy the inclusion and exclusion criteria. As a result, 15 articles were deemed eligible for further analysis.

After synthesizing government strategies through the SLR, semi-structured interviews with AEC professionals were conducted to validate the list and the completeness of the survey. This step entailed revising the language and technical terms used to develop the government strategies' descriptions and eliminating any confusion that emerged during the survey development process. It also included proposing government strategies not captured by the SLR and omitting irrelevant government strategies that were inapplicable to the Indonesian AEC industry. Finally, after receiving feedback and recommendations, the survey was finalized. Table 1 presents the 12 potential government strategies to enhance BIM implementation developed through the SLR and semi-structured interviews.

Table 1. Government strategies to enhance BIM implementation.

ID	Government Strategies	Source
GS01	Develop programs for improving BIM competencies	[1,54,56–59]
GS02	Provide financial aid to reduce the cost of implementing BIM	[56,60–62]
GS03	Develop BIM standards	[50,53,54,56,60]
GS04	Develop a digital transformation strategy for BIM	[1,49,50,58]
GS05	Mandate BIM implementation in the AEC industry	[51,52,54,56,60]
GS06	Develop programs to increase BIM awareness and understanding	[55,56,58]
GS07	Foster market demand for BIM	[50,55,56]
GS08	Initiate pilot projects to exploit evidence-based benefits of implementing BIM	[53,56,57]
GS09	Develop programs to integrate BIM into education curricula and academia	[54,57]
GS10	Develop BIM-related contractual frameworks	[54]
GS11	Develop BIM implementation guidelines	[53]
GS12	Create BIM institutes for training young/fresh graduates	[52]

The survey was divided into two main parts. Part I asked about the respondent profile. Part II asked respondents to assess the criticality of government strategies using a five-point Likert scale (1 = not critical, 2 = slightly critical, 3 = moderately critical, 4 = critical, and 5 = very critical). A blank space was also provided for respondents to describe and assess any additional government strategies. The survey was developed in English and Bahasa Indonesia to avoid rejection and attain a larger sample size.

3.2. Data Collection

The target population included all AEC professionals with sufficient knowledge and understanding of BIM. Because a sample frame was unavailable, using probability sampling techniques was not feasible. Instead, the non-probability sampling technique was adopted to obtain a representative sample. This technique can be used when random sharing is difficult to achieve [66]. This technique has also been used in several previous works on BIM as the whole population of BIM professionals is difficult to identify [12,20]. Convenience sampling was first applied to approach respondents with sufficient experience in BIM using the authors' referrals and network to obtain credible responses. Then, snowball sampling was used to increase the number of respondents [67]. Respondents that were initially approached were requested to propose any other AEC professionals that were appropriate for answering the survey. After multiple reminders and interactions, this study collected 163 valid responses.

Table 2 shows that most respondents were males and aged between 31 to 40 years old. Respondents with a bachelor's degree were dominant, with 56.44% of the total sample. The study sample represented many business types, with 44.79 consultants, 39.26% contractors, and 6.75% clients. The majority of organizations were located on Java Island (71.78%). Table 2 shows that only 3.07% of the sample had less than one year of working experience in the AEC industry. At the same time, the majority had 6 to 10 years of experience. Regarding BIM experience, the accumulative percentage of those having no experience and less than one year experience in BIM was 47.24%. In contrast, the remaining sample had greater than one year of experience using BIM. Given the working experience in the AEC industry and with BIM, the data could be relied upon for further analyses.

Table 2. Respondent profile.

Type of Distribution	Description	Frequency	%	Cumulative %
Gender	Male	129	79.14	79.14
	Female	34	20.86	100.00
	Total	163	100	
Age	<30	40	24.53	24.53
	31–40	59	36.2	60.73
	41–50	51	31.29	92.02
	>50	13	7.98	100.00
	Total	163	100	
Highest education level	Diploma	7	4.29	4.29
	Bachelor's	92	56.44	60.73
	Master's	57	34.98	95.71
	PhD	7	4.29	100.00
	Total	163	100	
Nature of business	Consultant	73	44.79	44.79
	Contractor	64	39.26	84.05
	Client	11	6.75	90.80
	Others	15	9.2	100.00
	Total	163	100	
Region of organization	Sumatera Island	30	18.41	18.41
	Java Island	117	71.78	90.19
	Kalimantan Island	3	1.84	92.03
	Sulawesi Island	1	0.61	92.64
	Others	12	7.36	100.00
	Total	163	100	
Working experience in the AEC industry	<1	5	3.07	3.07
	1–5	28	17.18	20.25
	6–10	42	25.77	46.02
	11–15	35	21.47	67.49
	16–20	29	17.79	85.28
	>20	24	14.72	100.00
	Total	163	100	
Working experience in using BIM	None	46	28.22	28.22
	<1	31	19.02	47.24
	1–5	49	30.06	77.30
	6–10	26	15.95	93.25
	11–15	10	6.14	99.39
	16–20	1	0.61	100.00
	Total	163	100	

3.3. Data Analysis

3.3.1. Reliability Testing

Before embarking on the data analysis, the reliability was assessed using Cronbach's alpha. Cronbach's alpha is a common technique for testing the reliability of a survey [58,68]. Cronbach's alpha values span from 0.00. to 1.00. A value closer to 1.00 indicates higher reliability of the data collection instrument, and a value closer to 0.00 suggests that the questionnaire should be further improved to increase internal consistency. The Cronbach's alpha value for this study was 0.953, signifying that the data had high reliability [69].

Furthermore, a Kruskal–Wallis test was conducted to explore any significant differences among respondent groups with different levels of experience with BIM. The results illustrated that only one strategy had significantly different means between respondent groups at p-value < 0.05: 'mandate BIM implementation in the AEC industry' (p-value = 0.031). The results illustrated that the differences in the opinions among respondents with different levels of experience with BIM were minimal. Therefore, the data were not differentiated according to the level of experience with BIM in subsequent analyses.

3.3.2. Ranking Analysis

After ensuring the reliability of the data, the mean score was used to rank the government strategies. The standard deviation (SD) was also computed to rank the strategies with the same means. For example, if two government strategies or more had the same mean, the strategy with a lower SD was ranked higher. Finally, the normalized value technique was used to identify the critical government strategies. Any government strategy with a normalized value greater than 0.50 was identified as critical. Construction management research has used similar techniques to identify key success factors for implementing concrete recycling in construction projects and critical strategies for enhancing organizational BIM capabilities [70,71].

3.3.3. Overlap Analysis

The overlap analysis technique was based on the ranking results to identify the common and unique critical government strategies between construction project stakeholders (e.g., consultant, contractor, and client). The overlap analysis technique is a decision-making technique to compare similarities and differences between multiple categories [72,73]. Government strategies for at least two stakeholders shape the overlap, and those unique to a specific stakeholder shape the non-overlap part.

3.3.4. Agreement Analysis

This study sample was categorized into subgroups according to the main construction project stakeholders (i.e., consultants, contractors, and clients) and BIM experience. The Kruskal–Wallis test explored discrepancies among consultants, contractors, and clients regarding the criticality of overlapping government strategies. Kruskal–Wallis is a non-parametric test that can analyze Likert scale data from at least three groups when the normality assumption is unjustified [74]. The null hypothesis entails no significant differences in the means between stakeholders (p-value ≥ 0.05) [74]. When the null hypothesis is rejected (p-value ≤ 0.05)), a post hoc analysis should be further conducted to investigate the differences in which pairs of stakeholders exist. Finally, the Mann–Whitney test was employed to examine any potential differences in the means of the overlapping government strategies between two stakeholders [71].

3.3.5. Correlation Analysis

Finally, a correlation analysis was carried out to analyze the relationships between the government strategies using Spearman rank-order correlation analysis. This analysis measures the strength of the association between two variables [75]. The correlation coefficients between the government strategies were calculated and interpreted as follows: 0.00 to 0.29 as little if any correlation; 0.30 to 0.49 as low correlation; 0.50 to 0.69 as moderate correlation; 0.70 to 0.89 as high correlation; and 0.90 to 1.00 as very high correlation [76].

4. Results

4.1. Results of Ranking Analysis

Table 3 presents the ranking of the government strategies to enhance BIM implementation in Indonesia. The mean scores of the strategies range from 3.669 to 3.914. Strategies with at least a 0.50 normalized value were identified as critical. Accordingly, six government strategies had a normalized value greater than 0.50 and thus were identified as critical. The most critical government strategy to enhance BIM implementation in Indonesia was ‘develop programs to integrate BIM into education curricula and academia’ (mean = 3.914). The other top five critical government strategies were ‘develop BIM implementation guidelines’ (Mean = 3.908), ‘develop BIM standards’ (mean = 3.990), ‘develop a digital transformation strategy for BIM’ (mean = 3.589), ‘initiate pilot projects to exploit evidence-based benefits of implementing BIM' (mean = 3.589), and 'develop BIM-related contractual frameworks' (mean = 3.810).

Table 3. Ranking of government strategies to enhance BIM implementation.

ID	Consultant (n = 73)				Contractor (n = 64)				Client (n = 11)				Overlapping Stakeholders	Agreement
	M	SD	NV	R	M	SD	NV	R	M	SD	NV	R		
GS11	3.849	1.0629	1.000 *	1	3.984	1.0464	0.556 *	6	4.182	0.8739	1.000 *	1	All	0.475
GS09	3.808	1.1626	0.800 *	2	4.000	0.9759	0.611 *	4	4.091	0.9439	0.800 *	4	All	0.813
GS03	3.740	1.2137	0.680 *	3	4.109	0.9614	1.000 *	1	3.818	0.6030	0.200	10	Cons&Cont	0.094
GS04	3.712	1.1958	0.600 *	4	4.063	0.9900	0.833 *	2	3.909	0.5394	0.400	5	Cons&Cont	0.095
GS08	3.685	1.1532	0.520 *	5	4.031	0.8903	0.722 *	3	3.909	0.7006	0.400	6	Cons&Cont	0.108
GS02	3.671	1.1909	0.480	6	3.953	1.0901	0.444	9	3.818	0.8739	0.200	11	-	-
GS12	3.644	1.2176	0.400	7	3.875	1.1198	0.167	11	4.091	0.8312	0.800 *	3	-	-
GS06	3.616	1.0882	0.320	8	3.984	0.9676	0.556 *	5	3.909	0.5394	0.400	5	-	-
GS10	3.616	1.1258	0.320	9	3.969	0.9915	0.500 *	8	4.182	0.8739	1.000 *	1	Cont&Clie	0.569
GS05	3.603	1.1636	0.280	10	3.906	1.0797	0.278	10	3.909	0.5394	0.400	5	-	-
GS01	3.562	1.1783	0.160	11	3.969	0.9080	0.500 *	7	3.909	0.5394	0.400	5	-	-
GS07	3.507	1.1917	0.000	12	3.828	0.9849	0.000	12	3.727	0.6467	0.000	12	-	-

M = Mean score; NV (normalized value) = mean–minimum mean/maximum mean–minimum mean; R = Rank; Cons = Consultant; Cont = Contractor; Clie = Client; * indicates that the strategy is critical.

4.2. Results of Overlap Analysis

The overlap analysis technique was conducted to identify the critical government strategies shared between at least two stakeholders. The mean score, SD, and normalized values were computed for each stakeholder separately (Table 3). As shown in Figure 1, the overlapping critical government strategies between all stakeholders were 'develop programs to integrate BIM into education curricula and academia' and 'develop BIM implementation guidelines.' The overlapping critical government strategies between consultant and contractor were 'develop BIM standards,' 'develop a digital transformation strategy for BIM,' and 'initiate pilot projects to exploit evidence-based benefits of implementing BIM.' The overlapping critical government strategy between contractor and client was 'develop BIM-related contractual frameworks.' The results illustrate that there were no overlapping critical strategies between consultant and client except for those overlapping between all stakeholders.

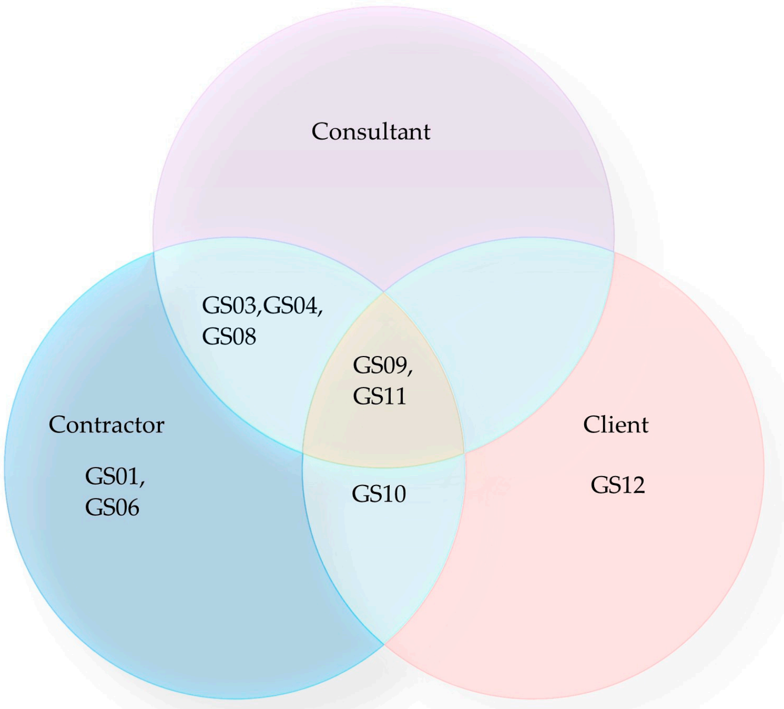

Figure 1. Overlapping critical government strategies between stakeholders.

4.3. Results of Agreement Analysis

Kruskal–Wallis and Mann–Whitney tests were performed to examine any significant differences in the response mean scores based on respondent profession. Table 3 shows the results of the agreement analysis for the six overlapping critical government strategies. The results of the Kruskal–Wallis and Mann–Whitney tests illustrate that all the values were greater than 0.05, indicating no significant differences in the criticality of the overlapping government strategies between stakeholders.

4.4. Results of Correlation Analysis

Table 4 shows Spearmen's correlation coefficients (ρ) between the government strategies. The results illustrate that most government strategies had a moderate correlation. In addition, some government strategies had low and high correlations. The high correlations were between 'develop BIM standards' and 'develop a digital transformation strategy for BIM' (ρ = 0.747), 'initiate pilot projects to exploit evidence-based benefits of implementing BIM' and 'develop BIM-related contractual frameworks' (ρ = 0.705), 'develop programs to integrate BIM into education curricula and academia' and 'develop BIM-related contractual frameworks' (ρ = 0.735), 'develop programs to integrate BIM into education curricula and academia' and 'develop BIM implementation guidelines' (ρ = 0.700), 'develop BIM implementation guidelines' and 'develop BIM-related contractual frameworks' (ρ = 0.772), and 'create BIM institutes for training young/fresh graduates' and 'develop BIM implementation guidelines' (ρ = 0.697).

Table 4. Correlation analysis.

ID	GS01	GS02	GS03	GS04	GS05	GS06	GS07	GS08	GS09	GS10	GS11	GS12
GS01	1.000	0.482 **	0.582 **	0.568 **	0.538 **	0.603 **	0.626 **	0.491 **	0.567 **	0.557 **	0.493 **	0.587 **
GS02	0.482 **	1.000	0.450 **	0.542 **	0.427 **	0.480 **	0.524 **	0.470 **	0.435 **	0.411 **	0.434 **	0.570 **
GS03	0.582 **	0.450 **	1.000	0.747 **	0.645 **	0.656 **	0.622 **	0.545 **	0.570 **	0.605 **	0.677 **	0.630 **
GS04	0.568 **	0.542 **	0.747 **	1.000	0.617 **	0.681 **	0.609 **	0.627 **	0.656 **	0.602 **	0.650 **	0.559 **
GS05	0.538 **	0.427 **	0.645 **	0.617 **	1.000	0.684 **	0.666 **	0.640 **	0.507 **	0.573 **	0.550 **	0.500 **
GS06	0.603 **	0.480 **	0.656 **	0.681 **	0.684 **	1.000	0.644 **	0.597 **	0.625 **	0.656 **	0.639 **	0.646 **
GS07	0.626 **	0.524 **	0.622 **	0.609 **	0.666 **	0.644 **	1.000	0.659 **	0.500 **	0.578 **	0.566 **	0.584 **
GS08	0.491 **	0.470 **	0.545 **	0.627 **	0.640 **	0.597 **	0.659 **	1.000	0.631 **	0.705 **	0.660 **	0.586 **
GS09	0.567 **	0.435 **	0.570 **	0.656 **	0.507 **	0.625 **	0.500 **	0.631 **	1.000	0.735 **	0.700 **	0.584 **
GS10	0.557 **	0.411 **	0.605 **	0.602 **	0.573 **	0.656 **	0.578 **	0.705 **	0.735 **	1.000	0.772 **	0.604 **
GS11	0.493 **	0.434 **	0.677 **	0.650 **	0.550 **	0.639 **	0.566 **	0.660 **	0.700 **	0.772 **	1.000	0.697 **
GS12	0.587 **	0.570 **	0.630 **	0.559 **	0.500 **	0.646 **	0.584 **	0.586 **	0.584 **	0.604 **	0.697 **	1.000

** Correlation significant at the 0.01 level (2-tailed).

5. Discussion

5.1. Develop Programs to Integrate BIM into Education Curricula and Academia

The study findings illustrate that integrating BIM into education curricula and academia (i.e., BIM education) offers an overlapping critical government strategy for enhancing BIM implementation in Indonesia. This finding is in line with other works stating that it is necessary to fully integrate BIM education in higher education institutions to increase knowledge about BIM and its implementation [54,57]. Therefore, an emphasis should be placed on the interaction between government and the educational sector to integrate BIM education. The shift towards BIM requires significant effort, time, and education on the new work processes, tools of modeling, and ways of communication [54]. BIM education can eliminate the lack of understanding and knowledge [77,78]. Beyond teaching BIM concepts and applications, a part of education relates to technical competency in specific BIM tools [79]. This requires technical education on transitioning from 2D to 3D parametric modeling and learning about BIM software. Due to the lack of BIM-trained professionals, organizations tend to retrain experienced CAD operators [2], which is often seen as costly and time-consuming [54]. BIM education can overcome the lack of trained BIM personnel and generate BIM-ready employees, reducing the financial burden on organizations [80]. Through BIM education, undergraduates can grasp opportunities to become BIM professionals with the specific skills needed to succeed at the operational level.

To integrate BIM into education curricula and academia, the government and educational sector should effectively interact and share their experience of theory and practice on specific content and materials for BIM education. BIM education should start at a degree level where universities can establish the foundation and develop modules on BIM concepts and applications to sharpen the theoretical background of the students [54]. The involvement of industry professionals is also critical to ensure that BIM education and its modules can equip undergraduates with the knowledge and skills that meet the industry needs [78]. Alignment between the educational sector and professional bodies would also help develop BIM educational deliverables and learning plans. These modules require scoping and accreditation by authorities [55]. It is also essential for respective entities to find a space in established curriculums to include new courses on BIM. Through these initiatives, undergraduates should be more conversant with BIM and its processes.

5.2. Develop BIM Implementation Guidelines

The study findings also demonstrate that developing BIM implementation guidelines is another overlapping critical government strategy for enhancing BIM implementation in Indonesia. Ref. [53] found that it is inevitable that a clear set of guidelines outlining an effective strategy and methodology for BIM implementation needs to be developed. Ref. [81] stated that developing a regional-specific BIM implantation guideline is necessary because overseas guidelines may not be suitable for other countries. As BIM is fundamentally new, transitioning from traditional practice to BIM demands comprehensive information and guidelines on BIM implementation processes [53]. Accordingly, several BIM guidelines and standards have been issued, focusing on the specific needs of individual countries [82]. For example, the CRC-CI in Australia has issued guidelines and case studies focusing on open and consistent processes and testing selected software compatibility [83]. The Danish government has developed BIM guidelines for four components: 3D CAD Manual, 3D Working Method, Project Agreement and Layer, and Object Structures [84]. In Finland, BIM guidelines have been developed to provide general operational procedures in BIM projects and detailed general requirements of BIM models [79]. The USA has released a guide to help contractors understand how to get started with BIM [85]. In addition, the National Building Information Modeling Standard (NBIMS), developed by the USA, has provided standard definitions for BIM information exchanges [86]. These guidelines have been developed considering the local context. However, no BIM guidelines or standards are available in the Indonesian context [40]. Therefore, regional-specific BIM guidelines considering the Indonesian context are essential.

BIM guidelines are incompatible with all organizations due to different organizational cultures, procedures, sizes, and goals [79]. Thus, they should be developed considering the goals of BIM use and their alignment with organizational goals. It is also vital to identify the scope and use of BIM across the project phases (e.g., a checklist of BIM applications, such as the use of BIM for energy analysis or clash detection). In addition, the roles of participants in the BIM process and handovers between all participants should be clearly stated. The government can leverage publicly available guidelines and adjust its setting to comply with the local industry environment (e.g., language and symbols) [2]. This would help facilitate BIM implementation and provide organizations with consistent standards to use [53]. Thus, it becomes inevitable that a clear set of guidelines outlining an effective strategy and methodology for BIM implementation needs to be developed.

6. Study Implications

Unlike prior works that have focused on BIM use, barriers to BIM implementation, and BIM readiness, this study contributes to understanding the critical government strategies for enhancing BIM implementation in Indonesia. The findings demonstrate that integrating BIM into academia is a critical overlapping government strategy between the consultant, contractor, and client. The government and education sector can share their efforts, experiences, and resources to develop BIM education programs and modules to enhance BIM knowledge for graduates. Furthermore, developing BIM implementation guidelines is essential. The government and professional bodies should interact and develop BIM guidelines with clear directions and instructions for BIM implementation processes. As different countries vary in economic development, business culture, and individual attitude, this study provides insights into the most effective strategies to promote BIM implementation in Indonesia. Accordingly, the findings will enhance BIM implementation and help embrace the next wave of innovations, such as digital twins, which enable AEC organizations to assess infrastructure performance in real time and adjust operations to optimize efficiency.

7. Limitations and Future Directions

Although the study objectives were achieved, there are some limitations worth stating. The sample size was relatively small. Future research can target a higher sample size to generalize the findings. As the respondents were selected using non-probability sampling, the findings may hold a biased view of the respondents' characteristics (e.g., respondents' BIM experience). Nevertheless, the Kruskal–Wallis test suggests minimal differences in the criticality of the government strategies based on BIM experience. In other words, the respondents with different BIM experiences have the same view on the criticality of government strategies. As this study was quantitative, a qualitative approach (e.g., interviews) can be a future research direction to validate the findings. The study was confined to Indonesia, and different conclusions may be drawn from different countries. This study did not adopt a specific definition of BIM. The definition of BIM should be articulated in future research for more informative findings. As this study aimed to extract the government strategies addressed in the literature, it did not adopt any theory (e.g., diffusion of innovation theory) as a foundation. Future research can also consider the goal-driven approach, as BIM implementation and projects are considered successful when predefined goals are achieved. Thus, BIM implementation varies depending on the goals of a specific project. Finally, this study adopted a similar pattern to previous works by focusing on the AEC industry, as works that focused on BIM implementation and its use in the architectural, engineering, construction, and operation (AECO) industry in Indonesia are limited. Future research can investigate BIM implementation at the operation stage. Nevertheless, this study provides insights into the critical strategies that should be implemented by the government to support BIM implementation in Indonesia.

8. Conclusions

This study examined government strategies to enhance BIM implementation in Indonesia. Through SLR and semi-structured interviews with AEC professionals, 12 government strategies were identified. A questionnaire survey was disseminated to AEC professionals to assess the criticality of government strategies in the Indonesian context. Data analysis involved mean score ranking, SD, normalization, overlap analysis, the Kruskal–Wallis test, and Spearman's correlation analysis.

The results revealed six critical government strategies to enhance BIM implementation in Indonesia. These strategies were 'develop programs to integrate BIM into education curricula and academia,' 'develop BIM implementation guidelines,' 'develop BIM standards,' 'develop a digital transformation strategy for BIM,' 'initiate pilot projects to exploit evidence-based benefits of implementing BIM,' and 'develop BIM-related contractual frameworks.' Therefore, these strategies should be given high priority and attention to facilitate the BIM implementation process.

The overlap analysis illustrated that two critical government strategies overlapped between all the professions (consultant, contractor, and client): 'develop programs to integrate BIM into education curricula and academia' and 'develop BIM implementation guidelines.' It is recommended that a structured BIM curriculum should be developed through the interaction of the educational sector and government to create BIM-capable graduates. This would reduce the challenges to BIM implementation, including time and cost for BIM training, and equip graduates with sufficient BIM knowledge and skills to enter the AEC market. Furthermore, developing BIM implementation guidelines is necessary to provide clear directions and instructions for BIM implementation and use. The government of Indonesia can exploit existing overseas BIM guidelines by reinterpreting and localizing their content to Indonesia. Agreement analysis demonstrates consistent views on the criticality of the overlapping government strategies between consultant, contractor, and client. Therefore, these strategies can be implemented to enhance BIM implementation in Indonesia regardless of the stakeholder.

This study contributed to the body of knowledge by analyzing government strategies to enhance BIM implementation in Indonesia. Scholars would benefit from the findings by concentrating their efforts and conducting more research on the critical government strategies that address professionals' concerns. Furthermore, the government can commit resources and actively engage with the educational sector to create BIM-capable graduates and develop BIM implementation guidelines to facilitate the BIM implementation process.

Author Contributions: Conceptualization, M.S.A.-M., M.S.R. and R.A.R.; methodology, M.S.A.-M. and R.A.R.; formal analysis, M.S.A.-M.; resources, M.S.A.-M., M.S.R. and R.A.R.; data curation, M.S.A.-M.; writing—original draft preparation, H.A.R. and M.S.A.-M.; writing—review and editing, M.S.A.-M., M.S.R. and R.A.R.; visualization, M.S.A.-M.; supervision, R.A.R.; project administration, M.S.R. and R.A.R. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by Universitas Muhammadiyah Aceh.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to the study involving anonymous data collection.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to some data being proprietary or confidential in nature. Therefore, the data may only be provided with restrictions (e.g., anonymized data).

Acknowledgments: We would like to acknowledge VT's OASF support for covering the fees for the publication of this article. The authors would like to thank all the practitioners who participated in this study.

Conflicts of Interest: The authors declare no conflict of interest.

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