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Managing Compliance in Digital Building Certification Systems: User Intention, Platform Usability, and SLF Participation in Indonesia

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Abstract: Building occupancy certification is a key mechanism for managing post-construction compliance, covering building safety, functional readiness, and legal operability. In Indonesia, this function is carried by the SLF (*Sertifikat Laik Fungsi*, Certificate of Functional Worthiness), yet fewer than 10% of buildings nationwide hold one. This study asks what drives participation in SLF certification, looking at both behavioural and system-level factors within the country's digital building certification system. Using a sequential explanatory mixed-methods design, we analysed 270 valid survey responses from Semarang, Sidoarjo, and Bandung with partial least squares–structural equation modelling (PLS-SEM), then drew on focus group discussions (FGDs) with government officials, consultants, technical experts, and business associations to interpret the results. The quantitative results show that intention to obtain an SLF is the strongest predictor of participation, supported by knowledge and perceived ease of use of the SIMBG (*Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System) platform. Technical and bureaucratic barriers did not show a statistically significant negative effect in the expected direction. However, the qualitative findings reveal that high consultant costs, weak document validation, inconsistent local requirements, limited technical staff capacity, and unclear institutional coordination remain important obstacles in the certification workflow. The study contributes to engineering management by repositioning SLF participation as part of a digital building compliance management process rather than merely an administrative or public service issue. The findings indicate that improving SLF participation requires not only awareness campaigns, but also workflow-level interventions, including document pre-checking, standardised technical submission templates, cost estimation tools, application tracking, and clearer coordination between central platform managers and local technical agencies.

Keywords: Sertifikat Laik Fungsi; Certification workflow; Sistem Informasi Manajemen Bangunan Gedung; Compliance management; Building occupancy certification

1 Introduction

Building occupancy certification is a critical component of engineering compliance management in the architecture, engineering, and construction (AEC) sector. Beyond its administrative function, occupancy certification serves as a post-construction control mechanism to verify that completed buildings satisfy technical standards, safety requirements, functional readiness, and legal operability before use. Across jurisdictions, building compliance management generally involves technical document review, permit issuance, site inspection, and the issuance of completion or occupancy certificates [1, 2]. In Indonesia, this mechanism is represented by the SLF (*Sertifikat Laik Fungsi*, Certificate of Functional Worthiness), or Building Occupancy Certificate, which confirms that a building has met technical requirements related to safety, health, comfort, accessibility, and environmental sustainability as mandated under Law No. 11 of 2020 and Government Regulation No. 16 of 2021. Despite its importance for

building safety control and post-construction accountability, SLF certification in Indonesian municipalities remains low—less than 10% on average—while many buildings only obtain the PBG (*Persetujuan Bangunan Gedung*, Building Approval) without proceeding to occupancy certification.

To support the management of building certification, the Indonesian government has introduced the SIMBG (*Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System), a national digital platform for building permit and occupancy certification processes. In the context of engineering management, SIMBG should not be understood merely as an online public service portal, but as a digital certification workflow that coordinates technical document submission, administrative screening, engineering review, correction cycles, and final approval. Similar to digital building permit systems in other countries, such platforms are expected to improve document traceability, reduce manual errors, support workflow monitoring, and enhance coordination among applicants, consultants, local technical agencies, and central platform managers [1, 3, 4]. However, implementation challenges remain in Indonesia, including weak document validation, inconsistent local requirements, costly consultant involvement, limited technical staff capacity, and unclear coordination between local agencies and central system administrators. These challenges indicate that low SLF participation is not only a behavioural or administrative issue, but also a building certification workflow management problem.

Globally, scholars have examined building certification, permit approval, and code compliance from several related perspectives. Studies highlight technical and administrative bottlenecks in certification processes [5], while systems engineering literature emphasises that compliance should be understood as an integrated operational process involving regulatory interpretation, process coordination, monitoring, and feedback loops [6]. Research on e-permit systems in construction also shows that digital permitting environments depend on multi-level stakeholder interaction, inter-agency communication, process redesign, and coordination among applicants and public officials [7]. This perspective is relevant to SIMBG because digital building certification depends not only on platform availability, but also on technological readiness, organisational support, external conditions, and the ability of users and institutions to integrate digital systems into operational workflows [8]. Other studies on safe building codes further show that building safety compliance depends on institutional and community awareness, regulatory enforcement, and the ability of stakeholders to translate technical rules into actual compliance practices [9]. Yet, less attention has been given to how users participate in digital certification workflows in developing-country contexts where platforms are already implemented but compliance uptake remains low [10–12].

Recent studies on digital building permits and automated compliance checking show that building certification systems increasingly depend on integrated digital workflows, technical document standardisation, model-based checking, and multi-stakeholder coordination. Digital permit systems can improve efficiency by enabling electronic submission, pre-checking, application tracking, and compliance verification, but their effectiveness depends on data quality, organisational readiness, user capability, and the alignment of responsibilities among authorities and technical actors [13–16]. However, much of this literature focuses on advanced Building Information Modelling (BIM)-based or automated compliance checking systems, while less attention has been given to how users participate in digital certification workflows in developing-country contexts where platforms are already implemented but compliance uptake remains low. This study addresses this gap by examining SLF participation as part of a digital building certification compliance system.

Building on this gap, the present study develops and tests a model explaining how knowledge, perceived ease of use, technical and bureaucratic barriers, and intention affect participation in SLF certification. Using a sequential explanatory mixed-methods design, the research combines survey-based quantitative analysis with qualitative insights from focus group discussions (FGDs) involving government officials, consultants, and business associations in Semarang, Sidoarjo, and Bandung.

The contribution of this study is threefold. First, it reframes SLF participation as part of building certification compliance management, linking behavioural participation with post-construction safety verification, technical document workflow, and approval coordination. Second, it empirically tests how knowledge, perceived ease of use, barriers, and intention influence participation in a digital building certification system, thereby connecting behavioural adoption theory with engineering compliance management. Third, it provides practical recommendations for improving SIMBG as a certification workflow platform, including document pre-checking, technical submission templates, cost transparency, application tracking, and clearer coordination among building owners, consultants, local technical agencies, and central platform managers.

Importantly, this study provides a nuanced perspective by demonstrating that bureaucratic and technical barriers, commonly assumed to be dominant in developing-country contexts, may not significantly affect participation when digital systems are already in place. This finding suggests a shift in focus from procedural constraints toward usability, cost perception, and institutional coherence in digital governance. By positioning SLF as a post-construction compliance mechanism and SIMBG as a digital certification workflow, this study contributes to engineering management by explaining how user intention, platform usability, and workflow barriers shape participation in building safety certification systems.

2 Literature Review and Hypotheses Development

2.1 Building Certification Compliance Management and Digital Workflow Systems

Building certification compliance management refers to the set of procedures through which regulatory authorities and technical actors verify whether proposed or completed buildings comply with applicable building codes, engineering standards, safety requirements, and occupancy conditions. In many jurisdictions, this process includes technical document review, permit approval, site inspection, correction cycles, and the issuance of completion or occupancy certificates [1, 2]. As such, occupancy certification should be understood not only as an administrative output, but also as a post-construction engineering control mechanism that confirms building operability, safety accountability, and readiness for use.

Traditional building certification and permit processes are often paper-based, labour-intensive, fragmented, and prone to errors. Previous studies show that manual workflows may lead to information loss, inconsistent interpretation of requirements, long processing times, and weak coordination among applicants, consultants, building authorities, and other technical agencies [1, 15]. These challenges have encouraged the development of digital building permit systems, e-permitting platforms, and automated compliance checking mechanisms in the AEC sector.

Digital building permit systems are designed to support electronic submission, document tracking, technical review, workflow control, and compliance verification. More advanced systems incorporate BIM, Geographic Information Systems (GIS), openBIM standards, and automated rule checking to improve the accuracy and efficiency of building approval processes [3, 4, 14]. Automated compliance checking literature further highlights the importance of digital representations of building objects, computable regulatory requirements, pre-submission checking, and human expert oversight in ensuring that digital systems support rather than replace professional judgement [13, 16].

From a systems engineering perspective, digital certification platforms are socio-technical systems involving platform functionality, document quality, technical agencies, applicants, consultants, and regulatory workflows. The effectiveness of such systems depends not only on automation, but also on user capability, organisational coordination, information flow, and the clarity of roles across the certification process [15, 17, 18]. Therefore, public participation in SLF certification can be examined as part of a broader digital building compliance management system, where user intention and platform usability influence whether technical certification workflows are successfully completed.

2.2 Public Participation in Digital Building Certification Workflows

In digital building certification systems, participation refers to the willingness and ability of building owners or their representatives to engage with the certification workflow, submit required technical documents, respond to correction requests, and complete the approval process. While participation remains related to governance and public service delivery, in the context of SLF it also reflects the capacity of users to interact with a technical compliance system. In Indonesia, the government introduced the SIMBG to integrate licensing and certification for the SLF. Despite the availability of a national digital certification workflow, SLF certification remains below 10% nationwide. This condition suggests that the existence of a digital platform alone is insufficient when users face difficulties in understanding technical requirements, navigating document submission procedures, and coordinating with consultants or technical agencies. Similar challenges have been reported in digital building permit and compliance systems, where workflow completion depends on document quality, user capability, platform functionality, and institutional coordination [1, 3, 4, 17].

2.3 Knowledge and Intention in Certification Compliance

Knowledge of regulatory and technical requirements plays a central role in building certification compliance. In the context of SLF, applicants need to understand not only the legal obligation to obtain certification, but also the required technical documents, submission sequence, correction procedures, and the role of consultants or local technical agencies in the approval workflow. From the perspective of the Theory of Planned Behavior (TPB), such knowledge can strengthen intention by increasing awareness of requirements and perceived readiness to act [19, 20]. In digital certification workflows, knowledge also helps users interpret platform instructions, prepare compliant documents, and respond to technical review feedback. Therefore, knowledge is expected to influence intention to obtain an SLF, although its direct effect on actual participation may still depend on workflow usability, cost, and institutional support.

H1. Knowledge about SLF positively influences the intention to obtain an SLF.

H2. Knowledge about SLF positively influences public participation in SLF certification.

2.4 Platform Usability and Certification Workflow Completion

The Technology Acceptance Model (TAM) identifies perceived ease of use as an important determinant of technology adoption [21]. In a digital building certification system, however, platform usability is not only a matter of user convenience; it also affects whether applicants can complete technical document submission, identify

missing requirements, correct errors, monitor application progress, and respond to review outcomes. Digital building permit studies show that electronic submission, pre-checking, workflow tracking, and structured review processes can reduce manual errors and improve approval efficiency when the platform is supported by clear data requirements and institutional coordination [1, 3, 4]. Applied to SLF, an intuitive and reliable SIMBG platform may strengthen users' intention to apply and increase their likelihood of completing the certification workflow.

H3. Ease of use of SIMBG positively influences the intention to obtain an SLF.

H4. Ease of use of SIMBG positively influences public participation in SLF certification.

2.5 Barriers in Building Certification Compliance

Barriers in building certification compliance may arise from several sources, including technical document complexity, unclear workflow requirements, weak platform validation, inconsistent local rules, limited institutional capacity, and the cost of professional assistance. In digital building permit and compliance systems, such barriers are often linked to fragmented information flows, manual interpretation of requirements, limited interoperability, and insufficient organisational readiness [13, 15, 16]. In the SLF context, these barriers may affect whether applicants are willing and able to proceed through the certification workflow, particularly when technical documents must be corrected repeatedly or when consultant costs are perceived as too high. From a TPB perspective, barriers may weaken perceived behavioural control and reduce the likelihood that intention is translated into participation. However, the effect of barriers may depend on the specific type of barrier measured, since procedural, technical, financial, and institutional barriers may not operate in the same way.

H5. Technical and bureaucratic barriers negatively influence the intention to obtain an SLF.

H6. Technical and bureaucratic barriers negatively influence public participation in SLF certification.

2.6 Intention as a Driver of Certification Participation

TPB casts intention as the immediate antecedent of behaviour [19, 20]. For SLF certification, intention captures an applicant's readiness to start and finish the workflow: preparing technical documents, submitting through SIMBG, answering correction requests, coordinating with consultants or agencies, and following the process to approval. It is thus not a general willingness to use a digital service but a behavioural driver of participation in a post-construction compliance process. Stronger intention should make applicants more likely to move from awareness of SLF requirements to actual participation.

H7. Intention to obtain an SLF positively influences public participation in SLF certification.

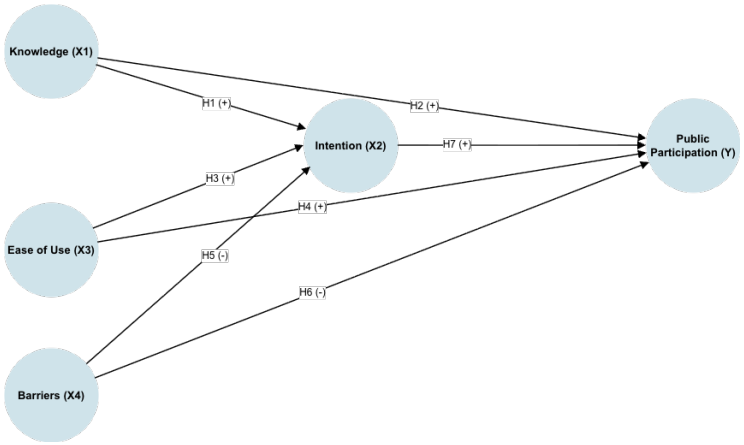

Figure 1. Conceptual framework for SLF certification participation

Note: SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness.

2.7 Conceptual Framework

Building on the literature on building certification compliance management, digital workflow systems, TPB, and TAM, this study develops a model of participation in SLF certification as a digital building compliance process. Knowledge is expected to strengthen intention and may also directly support participation by helping applicants understand technical and procedural requirements. Ease of use is expected to influence both intention and participation because platform usability affects applicants' ability to submit documents, correct errors, and monitor certification progress. Barriers are expected to weaken intention and participation by increasing perceived difficulty in completing the workflow. Finally, intention is expected to serve as the immediate behavioural driver of participation in the SLF certification process. The conceptual relationships among knowledge, ease of use, barriers,

intention, and public participation are illustrated in Figure 1. At the conceptual level, Public Participation (Y) is retained as the dependent construct of the model. Its empirical interpretation in the final measurement model follows the retained valid indicators after measurement assessment.

3 Methodology

3.1 Research Design

This study employed a sequential explanatory mixed-methods design, combining quantitative and qualitative approaches in two consecutive phases. The quantitative phase was prioritised to test the structural model and examine relationships among latent constructs using survey data and partial least squares–structural equation modelling (PLS-SEM). The subsequent qualitative phase involved FGDs with key stakeholders to further interpret and contextualise the statistical findings. This design was chosen because it enables the integration of empirical evidence with stakeholder insights, providing a more comprehensive understanding of participation in SLF certification and the operation of SIMBG as a digital building certification workflow.

3.2 SLF Application Workflow Through SIMBG

To clarify the system context for readers outside Indonesia, this study includes an author-generated process diagram of the SLF application workflow through SIMBG, as shown in Figure 2. The diagram is not intended to reproduce the official SIMBG interface, but to summarise the main actors, document flows, correction loops, technical review, approval decisions, and final SLF issuance process relevant to this study. The workflow was developed based on SIMBG applicant guidance, relevant PUPR regulation, and qualitative findings from the FGDs.

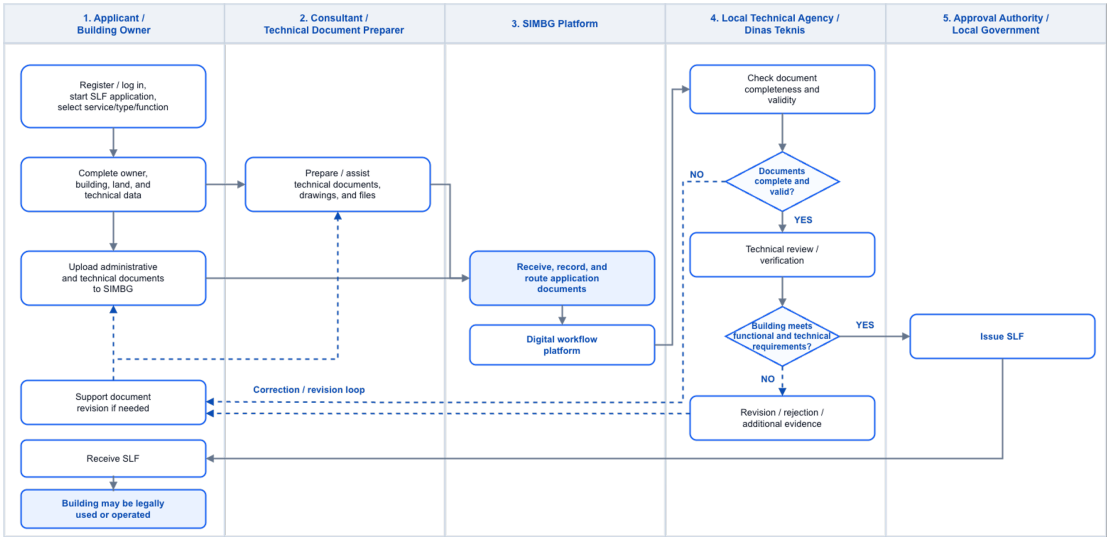

Figure 2. SLF application workflow through SIMBG

Note: SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness; SIMBG = *Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System.

In general, the process begins when the applicant or building owner accesses SIMBG and starts a new SLF application. The applicant then selects the SLF service, specifies the application type and building function, completes owner, building, land, and technical data, and uploads the required administrative and technical documents. Consultants or technical document preparers may assist applicants in preparing technical drawings, building data, and supporting compliance documents.

After submission, SIMBG functions as a digital workflow platform that receives, records, and routes the application documents. The local technical agency then checks the completeness and validity of the submitted documents. If the documents are incomplete or incorrect, correction requests are sent to the applicant and, when necessary, the consultant for revision and resubmission. If the documents are complete, the application proceeds to technical review, which may include document assessment, verification, and coordination with technical officers or expert teams. The application may be approved, returned for revision, or rejected depending on whether the building meets the required functional and technical standards. When the application satisfies the requirements, the relevant approval authority issues the SLF, allowing the building to be legally used or operated.

Operationally, these stages are interdependent. The quality of document preparation affects the completeness of the submission received by SIMBG and the local technical agency. Incomplete or inaccurate documents increase the burden of technical checking, trigger correction requests, and return the application to the applicant or consultant

for revision. These revision loops may restart document verification and delay final approval. Coordination pressure therefore tends to occur at three points: before submission, when applicants and consultants prepare technical documents; during completeness and technical checking, when SIMBG and local technical agencies verify document adequacy; and during revision, when applicants, consultants, and technical officers must interpret correction requests consistently.

3.3 Quantitative Phase

3.3.1 Population and sample

The population comprised building owners, building managers, business representatives, consultants, and other stakeholders who had direct or indirect experience with building licensing and SLF-related procedures. The respondents were classified as actual or potential SLF/SIMBG applicants or applicant-side representatives. Building owners represented direct applicants, while managers, business representatives, consultants, and other stakeholders were included because they prepare, manage, assist, or evaluate SLF/SIMBG applications in practice. The study focused on three urban municipalities in Indonesia: Semarang, Sidoarjo, and Bandung. These locations were selected purposively because they represent urban areas where SLF implementation and SIMBG-based licensing are relevant to building certification practice, but where local administrative capacity, regulatory enforcement, and certification workflow conditions may differ.

Semarang was selected because it represents a municipality with relatively active local efforts to support SIMBG implementation, including the development of local assistance mechanisms for applicants. Sidoarjo was selected because it represents a rapidly developing urban-industrial area with growing building licensing demand and coordination needs between applicants, consultants, and local technical agencies. Bandung was selected because it represents a large urban municipality with complex building types, higher public service demand, and more diverse certification cases. Together, these three locations provide variation in local certification practice, administrative capacity, building-use characteristics, and digital licensing implementation.

A total of 300 responses were initially collected, with 100 responses targeted from each municipality. After data screening, 270 valid responses were retained for the final PLS-SEM analysis. Responses with incomplete answers or invalid response patterns were excluded to ensure data quality. The sampling technique was purposive, as respondents were selected based on their relevance to SLF and building licensing processes. Therefore, the findings should be interpreted as evidence from three urban municipalities with active SLF and SIMBG implementation contexts, rather than as a statistically representative sample of all regions in Indonesia.

3.3.2 Instrument development

The instrument measured five latent constructs: Knowledge of SLF and SIMBG (X1), Intention and Commitment to Obtain SLF (X2), Perceived Ease of Use of SIMBG (X3), Technical and Bureaucratic Barriers (X4), and Public Participation in SLF Application (Y). Public Participation (Y) initially used three indicators, Y1, Y2, and Y3. Since Y1 was later excluded during measurement assessment due to its low loading, the final empirical interpretation of Public Participation (Y) is based on the retained indicators, Y2 and Y3. Each construct was measured using multiple indicators on a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree.

The indicators were developed by adapting established behavioural constructs from TPB and TAM and by formulating context-specific items related to SLF regulation, SIMBG procedures, technical document requirements, and certification workflow participation. The questionnaire was administered in Indonesian, with the wording reported here given in English translation. Table 1 lists the constructs, item codes, item wording, and source or development basis.

3.3.3 Data analysis

PLS-SEM Analysis in SmartPLS 4, chosen for its suitability for predictive work and its robustness with complex models and modest samples. Measurement validity and reliability were first assessed through indicator reliability, convergent validity, composite reliability, Cronbach's alpha, and average variance extracted (AVE), then tested the structural model, using bootstrapping with 5,000 resamples to gauge the significance of path coefficients.

For the measurement model, indicator reliability was read from outer loadings, internal consistency from Cronbach's alpha and composite reliability, and convergent validity from AVE. The one public participation item, Y1, fell below the recommended loading threshold in the initial model and was removed from the final measurement model.

3.4 Qualitative Phase

3.4.1 Participants

The qualitative phase involved FGDs with key stakeholders, including local government officials from technical departments (*Cipta Karya* and *Distaru*, Directorate General of Human Settlements, Ministry of Public Works and Spatial Planning Office), professional associations (PHRI and KADIN), technical consultants, building users or

applicant representatives, researchers, and members of the TPA (*Tim Profesi Ahli*, Professional Expert Team) and TPT (*Tim Penilik Teknis*, Technical Assessment Team). The participants were selected purposively based on their expertise, experience, and direct involvement in SLF implementation, SIMBG usage, building licensing, technical document preparation, and local building compliance procedures. Three FGDs were conducted, one in each study municipality: Semarang, Sidoarjo, and Bandung. Each FGD involved at least 10 participants.

Table 1. Constructs and measurement items

Construct	Item Code	Item Wording	Source/Development Basis
Knowledge of SLF and SIMBG (X1)	X1.1	I know that SLF is required under Government Regulation No. 16/2021.	Developed from regulatory knowledge and SLF/SIMBG context.
	X1.2	I understand the steps and documents required to apply for SLF through SIMBG.	
	X1.3	I understand the benefits of SLF in ensuring building safety and legality.	
	X1.4	I know that sanctions may apply if a building does not have an SLF.	
Intention and Commitment to Obtain SLF (X2)	X2.1	I am willing to allocate time and effort to obtain SLF.	Adapted from TPB intention construct [19, 20].
	X2.2	I feel legally responsible for obtaining SLF.	Adapted from TPB intention and compliance context [19, 20].
	X2.3	Obtaining SLF is a priority for me as a building owner or representative.	
	X2.4	I intend to obtain SLF in the near future.	Adapted from TPB intention construct [19, 20].
Ease of Use of SIMBG (X3)	X3.1	The SIMBG interface is easy to understand and use.	Adapted from TAM perceived ease of use [21].
	X3.2	SIMBG accelerates and simplifies the SLF application process.	Adapted from TAM perceived usefulness and SLF/SIMBG context [21].
	X3.3	I feel comfortable accessing SIMBG at any time.	Adapted from TAM ease of use and accessibility context [21].
	X3.4	I believe that the data and processes in SIMBG are secure and accurate.	Adapted from TAM/trust in digital systems and SLF/SIMBG context [21].
Technical and Bureaucratic Barriers (X4)	X4.1	The SLF application procedure is too long and confusing.	Developed from technical and bureaucratic barrier context.
	X4.2	The technical requirements for SLF are difficult for me to fulfil.	Developed from technical barrier context.
	X4.3	I have difficulty obtaining assistance and information from the relevant local agencies.	Developed from bureaucratic and institutional support barrier context.
	X4.4	The SLF application process requires high time and financial costs.	Developed from cost/time barrier context.
Public Participation in SLF Application (Y)	Y1	I have previously applied for or obtained SLF (Removed from the final measurement model due to low loading).	Developed based on SLF participation context [19, 20].
	Y2	I plan to initiate the SLF application process within the next three months.	Developed based on SLF participation and behavioural readiness context [19, 20].
	Y3	I am confident that I can complete the SLF application process independently without third-party assistance.	Developed based on self-efficacy and SLF participation context [19, 20].

Note: SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness; SIMBG = *Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System; TPB = Theory of Planned Behavior.

3.4.2 Data collection

FGDs were conducted in Semarang, Sidoarjo, and Bandung. Each session lasted between 90 and 120 minutes and was recorded with participants' permission. No separate individual interviews were conducted; the qualitative data

were collected through the FGDs. The same semi-structured discussion guide was used across the three municipalities to ensure comparability of the qualitative data. The discussions covered experiences with SLF applications, SIMBG usage, document preparation and validation, cost and resource issues, technical and bureaucratic barriers, institutional coordination, and recommendations for improving SLF participation and certification workflow.

3.4.3 Data analysis

The qualitative data were analysed using thematic coding. The FGD recordings were transcribed verbatim, and the transcripts were read iteratively to identify recurring patterns. The coding process followed an inductive–deductive approach. Initial codes were developed based on the research constructs and FGD themes, including system usability, cost and resources, policy and governance, public awareness, and proposed solutions. Additional codes were added when new themes emerged from the data, such as weak document validation, repeated correction cycles, limited technical staff capacity, consultant cost issues, and unclear responsibility between central and local actors.

The coding was conducted by a single researcher and reviewed iteratively to ensure consistency among the transcripts, codes, and final themes. To improve credibility, the emerging themes were discussed with the research team and compared with the quantitative findings. Any unclear coding interpretation was revisited by returning to the transcript and field notes before the final themes were used to explain the quantitative results, particularly regarding why certain variables, such as technical and bureaucratic barriers, were not statistically significant predictors in the PLS-SEM model.

3.5 Methods Integration Procedure

Integration followed explanatory sequential logic. The quantitative phase mapped the statistical relationships among knowledge, ease of use, barriers, intention, and participation; the qualitative phase then explained and contextualised them through stakeholders' experience of SIMBG, document preparation, correction cycles, consultant costs, technical review, and coordination. The integrated reading came from comparing the PLS-SEM results with recurring FGD themes, especially where a relationship needed further explanation, such as the indirect role of knowledge and the non-significant effect of barriers.

As the data were self-reported, the potential for common method bias was considered; however, procedural remedies such as anonymous responses and careful questionnaire design were applied to minimise bias.

4 Results and Findings

4.1 Quantitative Results

The quantitative analysis was based on 270 valid survey responses retained after data screening from an initial collection of 300 responses across Semarang, Sidoarjo, and Bandung. The results are presented in two parts: the measurement model assessment and the structural model assessment.

4.1.1 Measurement model assessment

The measurement model was assessed before testing the structural relationships. Table 2 presents the descriptive statistics and measurement model results for all retained indicators. All retained indicators had outer loadings above 0.70, indicating acceptable indicator reliability. One public participation item (Y1) was excluded from the final model because its loading was below the recommended threshold in the initial measurement model.

Accordingly, Public Participation (Y) in the final model should be interpreted based on the retained indicators, which reflect respondents' near-term intention to proceed with SLF certification and their self-perceived capability to complete the process, rather than verified prior SLF application or ownership. Because Y1 was removed, the final participation construct should be interpreted as capturing respondents' near-term participation readiness and perceived capability to complete the SLF process, rather than prior actual SLF application or ownership. The retained constructs demonstrated satisfactory internal consistency and convergent validity, with composite reliability (CR) values ranging from 0.868 to 0.948 and AVE values ranging from 0.623 to 0.819. Cronbach's alpha values exceeded 0.70 for most constructs. Although the alpha value for public participation was slightly below 0.70 (0.698), its CR (0.869) and AVE (0.768) exceeded the recommended thresholds, supporting its retention in the model.

4.1.2 Structural model assessment

The structural model results are shown in Figure 3 and summarised in Table 3. Following the hypotheses, knowledge had a significant positive effect on intention to obtain an SLF (H1: $\beta = 0.445$, $t = 5.99$, $p < 0.001$), but its direct effect on participation was not significant (H2: $\beta = 0.089$, $t = 0.99$, $p = 0.320$). This indicates that knowledge primarily functions as a precursor to intention rather than as a direct driver of certification participation.

Ease of use of SIMBG had a significant positive effect on intention (H3: $\beta = 0.464$, $t = 6.77$, $p < 0.001$) and directly increased participation (H4: $\beta = 0.282$, $t = 2.87$, $p = 0.004$). These findings suggest that platform usability supports both users' willingness to apply and their ability to complete the certification workflow. Technical and bureaucratic barriers did not show statistically significant negative effects in the expected direction. The effect on

intention was negative but negligible and non-significant (H5: $\beta = -0.008$, $t = 0.25$, $p = 0.800$). The effect on Public Participation (Y) was positive but not statistically significant at the 5% level (H6: $\beta = 0.082$, $t = 1.94$, $p = 0.052$), and this direction is contrary to the hypothesised negative relationship. Therefore, H6 is not supported and should not be interpreted as evidence that barriers reduce Public Participation (Y) in the quantitative model. Finally, intention had a significant positive effect on participation (H7: $\beta = 0.399$, $t = 3.70$, $p < 0.001$), confirming its role as the strongest behavioural driver of respondents' readiness and perceived capability to proceed with SLF certification.

Table 2. Measurement model results

Construct	Item Code	Mean	SD	Loading	Cronbach's α	CR	AVE
Knowledge of SLF and SIMBG (X1)	X1.1	4.470	0.681	0.844	0.840	0.893	0.676
	X1.2	4.300	0.762	0.834			
	X1.3	4.481	0.724	0.794			
	X1.4	4.404	0.758	0.817			
Intention and Commitment to Obtain SLF (X2)	X2.1	4.422	0.704	0.826	0.797	0.868	0.623
	X2.2	4.444	0.696	0.802			
	X2.3	4.500	0.660	0.766			
	X2.4	4.319	0.790	0.760			
Ease of Use of SIMBG (X3)	X3.1	4.337	0.716	0.840	0.853	0.901	0.695
	X3.2	4.393	0.711	0.815			
	X3.3	4.374	0.723	0.863			
	X3.4	4.463	0.718	0.815			
Technical and Bureaucratic Barriers (X4)	X4.1	3.022	1.382	0.803	0.944	0.948	0.819
	X4.2	2.970	1.403	0.935			
	X4.3	2.981	1.397	0.928			
	X4.4	3.185	1.337	0.947			
Public Participation in SLF Application (Y)	Y2	4.033	0.964	0.876	0.698	0.869	0.768
	Y3	4.167	0.885	0.877			

Note: SD = standard deviation; CR = composite reliability; AVE = average variance extracted. Y1 was excluded from the final measurement model because its loading was below the recommended threshold in the initial model.

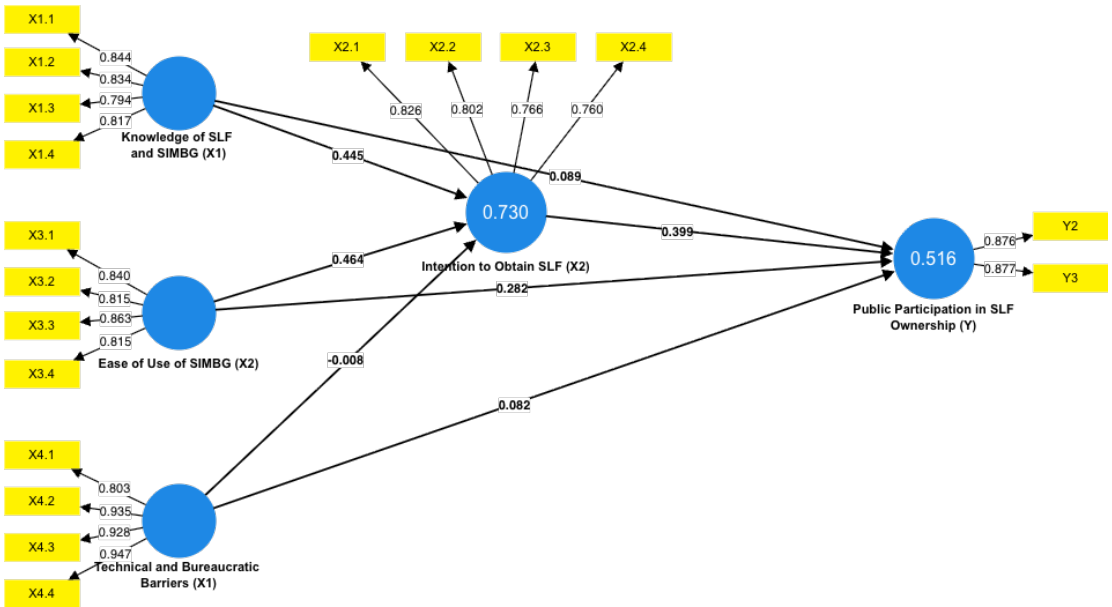

Figure 3. PLS-SEM structural model results

Note: SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness; SIMBG = *Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System; PLS-SEM = partial least squares–structural equation modelling.

Overall, the structural model shows that intention is the strongest behavioural driver of Public Participation (Y), as represented in the final model by respondents' readiness and perceived capability to proceed with SLF certification. Knowledge and ease of use support this process, while technical and bureaucratic barriers do not show a statistically significant direct effect in the quantitative model.

Table 3. Path coefficients of the partial least squares–structural equation modelling (PLS-SEM) structural model

Hypothesis	Relationship	Path Coefficient (β)	t-value	p-value	Result
H1	Knowledge → Intention	0.445	5.99	<0.001	Supported
H2	Knowledge → Participation	0.089	0.99	0.320	Not supported
H3	Ease of Use → Intention	0.464	6.77	<0.001	Supported
H4	Ease of Use → Participation	0.282	2.87	0.004	Supported
H5	Barriers → Intention	-0.008	0.25	0.800	Not supported
H6	Barriers → Participation	0.082	1.94	0.052	Not supported; direction contrary to hypothesis
H7	Intention → Participation	0.399	3.70	<0.001	Supported

Additional structural model criteria are presented in Table 4. The model explained 73.0% of the variance in intention and 51.6% of the variance in public participation, indicating substantial explanatory power for intention and moderate explanatory power for participation. The Standardised Root Mean Square Residual (SRMR) value was 0.059, indicating acceptable model fit. The inner Variance Inflation Factor (VIF) values ranged from 1.015 to 3.710, suggesting that multicollinearity was not a serious concern in the structural model. The effect size (f^2) results show that ease of use and knowledge had medium effects on intention, while intention had a small effect on participation. In contrast, the effect sizes of barriers were negligible to very small, which is consistent with the non-significant path results.

Table 4. Structural model quality criteria

Criterion	Construct/Relationship	Value	Interpretation
R^2	Intention and Commitment to Obtain SLF	0.730	Substantial explanatory power
Adjusted R^2	Intention and Commitment to Obtain SLF	0.727	Substantial explanatory power
R^2	Public Participation in SLF Application	0.516	Moderate explanatory power
Adjusted R^2	Public Participation in SLF Application	0.508	Moderate explanatory power
SRMR	Model fit	0.059	Acceptable model fit
Inner VIF	Range across structural paths	1.015–3.710	No serious multicollinearity issue
f^2	Ease of Use → Intention	0.330	Medium effect
f^2	Knowledge → Intention	0.305	Medium effect
f^2	Intention → Participation	0.089	Small effect
f^2	Barriers → Intention	0.000	Negligible effect
f^2	Barriers → Participation	0.014	Very small effect
f^2	Ease of Use → Participation	0.051	Small effect
f^2	Knowledge → Participation	0.005	Negligible effect

Note: SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness; SRMR = Standardised Root Mean Square Residual; VIF = Variance Inflation Factor.

4.2 Qualitative Findings

To deepen and contextualise the statistical results, FGDs were conducted with stakeholders in Semarang, Sidoarjo, and Bandung. Participants included government officials from technical departments, professional consultants, business associations such as KADIN and PHRI, and technical experts from TPA and TPT. The qualitative analysis identified several recurring themes that complement and explain the quantitative outcomes. The qualitative themes derived from the FGDs are summarised in Table 5, highlighting key issues related to system usability, costs and resources, governance fragmentation, public awareness, and proposed solutions.

First, the issue of system usability emerged repeatedly. Participants noted that SIMBG often allowed incorrect or incomplete documents to pass initial screening. For example, identity documents uploaded in the wrong category or placeholder codes (e.g., “00”) in technical fields were still accepted by the system. These flaws not only reduced

efficiency but also undermined public trust. In response, some municipalities such as Semarang developed a local *SIMBG Pendamping* (SIMBG assistance mechanism) to guide applicants through pre-validation before submission to the national platform.

Second, costs and resource limitations were highlighted as a major concern. Consultancy fees for SLF applications could reach Rp 10–15 million, which was prohibitive for small building owners. Additionally, local offices often lacked sufficient staff to process applications efficiently. In some cases, processing times extended up to three years due to document issues and limited human resources.

Third, policy and governance challenges were evident in the inconsistent implementation across municipalities. Local officials expressed concern that centralised platform governance limited the flexibility of local technical agencies to adapt the system to local implementation needs. Business representatives emphasised that the lack of standardised national guidelines created uncertainty, slowed investment, and placed Indonesia at a disadvantage compared with some regional competitors.

Fourth, public awareness was found to be high in terms of knowledge but low in terms of action. Many building owners knew that SLF was legally required yet refrained from applying due to perceived costs and complexity. This mirrors the quantitative finding that knowledge significantly shapes intention but not direct participation.

Finally, the discussions generated several proposed solutions. Stakeholders strongly supported the development of *SIMBG Asisten* (SIMBG Assistant), an auxiliary application designed to provide a checklist of requirements, a cost and time calculator, and validation tools to prevent submission errors. Other suggestions included allowing self-declaration for small buildings (under 500 m^2) to reduce reliance on costly consultants and offering standardised prototype building designs to streamline technical documentation.

Table 5. Thematic coding of FGD results

Theme	Evidence from FGDs	Interpretation
System usability	SIMBG allows incorrect/fake documents; Semarang developed SIMBG Pendamping	Weak validation reduces trust; local innovations help
Costs and resources	Consultancy fees up to Rp 15 million; staff shortages cause delays	High costs deter small owners; limited human resources prolong processing
Policy and governance	Centralised platform governance limits local technical flexibility; inconsistent municipal rules	Central–local coordination and clearer national guidelines are needed
Public awareness	Owners know SLF is required but do not apply	Knowledge shapes intention, but action blocked by costs/complexity
Proposed solutions	SIMBG Asisten, self-declaration for small buildings, prototype designs	Practical tools can reduce barriers and increase participation

Note: FGD = focus group discussion; SIMBG Pendamping = *Sistem Informasi Manajemen Bangunan Gedung*, Building Management Information System assistance mechanism; SLF = *Sertifikat Laik Fungsi*, Certificate of Functional Worthiness; SIMBG Asisten = SIMBG Assistant.

4.3 Integration of Quantitative and Qualitative Findings

The qualitative findings were used to explain and contextualise the quantitative results rather than to test the hypotheses independently. The PLS-SEM results show that intention and ease of use were significant predictors of Public Participation (Y), which in the final model reflects respondents' readiness and perceived capability to proceed with SLF certification, while knowledge influenced this construct indirectly through intention. The FGD findings help explain these patterns by showing that many applicants understand the importance of SLF but still need practical guidance, document preparation support, and confidence in using SIMBG before they proceed with the application.

The qualitative findings also clarify the interpretation of the non-significant result for barriers. While the quantitative model showed that technical and bureaucratic barriers did not significantly predict intention or participation, the FGDs revealed that barriers remain important at the workflow level. These barriers include consultant costs, weak document validation, repeated correction cycles, inconsistent municipal interpretation, limited technical staff capacity, and unclear institutional responsibilities. Therefore, the qualitative phase enriches the quantitative findings by identifying where friction occurs in the SLF certification workflow.

Overall, the mixed-methods results suggest that improving SLF participation requires more than increasing awareness. Participation depends on the interaction between behavioural readiness, platform usability, document quality, technical support, and institutional coordination. This integration supports the interpretation of SIMBG as a digital certification workflow system rather than merely an online licensing platform.

5 Discussion

The findings show that low SLF participation is not only a matter of limited awareness or willingness, but also reflects the way the certification workflow is experienced by applicants. In the Indonesian context, SLF certification requires building owners or their representatives to understand regulatory obligations, prepare technical documents, interact with SIMBG, respond to document corrections, coordinate with consultants or technical officers, and wait for technical review and approval. Therefore, the discussion focuses on how behavioural factors interact with workflow conditions in the SLF certification process.

5.1 From Awareness to Certification Workflow Completion

The quantitative results show that knowledge significantly influences intention, but does not directly influence participation. In line with the final measurement model, participation in this discussion refers to Public Participation (Y) as represented by the retained indicators, namely respondents' readiness and self-perceived capability to proceed with the SLF certification process. This pattern suggests an awareness–action gap in the SLF certification process. Many building owners may know that SLF is legally required, yet this awareness does not automatically lead to application submission or certification completion. The FGD findings explain this gap more clearly: applicants may understand the obligation, but still delay or avoid the process because they are unsure about technical document requirements, fear document rejection, perceive consultant costs as high, or lack confidence in navigating SIMBG independently.

This finding is important for engineering management because SLF participation depends on more than communication campaigns. Awareness must be translated into workflow capability. Building owners need practical guidance on what documents are required, how documents should be prepared, how correction requests should be handled, and how the application progresses through local technical review. Therefore, strengthening public knowledge should be linked with technical guidance, workflow checklists, and applicant support mechanisms rather than treated only as a public information issue.

5.2 Platform Usability and Document Validation in SIMBG

Ease of use had significant effects on both intention and participation, indicating that SIMBG usability is central to certification workflow completion. This finding is consistent with the Technology Acceptance Model, which emphasises perceived ease of use as an important condition for technology adoption [21]. However, in a digital building certification system, usability is not limited to whether applicants can access or operate the platform. It also concerns whether SIMBG helps applicants submit correct technical documents, identify missing requirements, receive clear error messages, monitor application progress, and reduce repeated correction cycles.

The FGD findings show that users experienced weak validation features, including cases where incorrect documents or placeholder codes could pass the initial submission stage. Such problems may reduce trust in the system and increase the burden on local technical reviewers. This finding is consistent with digital building permit literature showing that digital permit systems should support electronic submission, document tracking, technical review, workflow control, and compliance verification [1, 3, 4]. It also aligns with automated compliance checking literature, which emphasises the importance of reliable data inputs, computable requirements, pre-checking mechanisms, and human expert oversight in ensuring that digital systems support real-world permit approval workflows [13, 16].

This suggests that SIMBG should be strengthened as a workflow control platform. Practical improvements should include automatic document validation, mandatory field checking, file-type verification, pre-submission review, real-time error messages, and application tracking. These features would help applicants identify errors earlier and reduce unnecessary back-and-forth between applicants, consultants, and local technical agencies. In engineering management terms, platform usability should be understood as part of quality control in the certification workflow.

5.3 Reinterpreting Barriers in the SLF Certification Process

The quantitative results show that technical and bureaucratic barriers did not significantly affect intention or participation in the final model. This result should not be interpreted as evidence that barriers are unimportant. Rather, the qualitative findings help explain why the role of barriers is more complex than the quantitative model suggests. The survey items captured respondents' general perceptions of procedural and technical difficulty, such as long procedures, difficult technical requirements, limited assistance from local agencies, and time or financial burden. However, the FGDs revealed more specific workflow-level and institutional barriers, including consultant fee structures, weak platform validation, inconsistent municipal interpretation, limited technical staff capacity, and unclear institutional responsibilities.

One possible explanation is that barriers may not directly reduce intention, but may disrupt the translation of intention into actual participation. A building owner may intend to obtain SLF, but later postpone or abandon the process when consultant costs are perceived as too high, documents are repeatedly corrected, technical review takes

too long, or guidance from local agencies is insufficient. In this sense, the qualitative findings do not contradict the quantitative result; instead, they enrich its interpretation by showing where barriers emerge within the certification workflow.

The FGD findings further suggest that these barriers operate through specific process mechanisms. Consultant involvement is not only a cost issue, but also a coordination interface between applicants and the technical requirements of the certification system. Repeated document revision reflects both upstream document preparation problems and downstream validation limitations in SIMBG and local technical review. Local implementation differences create uncertainty because applicants and consultants may receive different interpretations of requirements across municipalities. Uncertainty during technical review also increases waiting time and makes it difficult for applicants to predict whether the application will be approved, returned for revision, or delayed. These process-level observations show that the main challenge is not simply the existence of barriers, but where they interrupt the certification workflow.

This interpretation is consistent with digital certification and engineering approval literature, which shows that certification workflows depend on information flow, document quality, organisational coordination, and the alignment of responsibilities among applicants, consultants, authorities, and technical professionals [14, 15, 17, 18]. Therefore, the non-significant quantitative result should be understood as a workflow interpretation issue rather than as proof that barriers do not matter. Future models should distinguish procedural barriers, technical document barriers, consultant cost barriers, platform validation barriers, municipal interpretation barriers, and institutional coordination barriers.

5.4 Engineering Management Implications for SLF Workflow Improvement

Practically, the findings indicate that improving SLF participation requires management actions at three levels: platform, organisational, and project levels. At the platform level, SIMBG should be strengthened as a digital certification workflow system rather than merely an online submission portal. Key actions include automatic document validation, mandatory field checking, file-type verification, real-time error messages, pre-submission review, cost and time estimation tools, and application progress tracking. These actions are consistent with digital building permit studies that emphasise the importance of electronic submission, document traceability, workflow monitoring, and compliance verification in improving permit and certification processes [1, 3, 4].

At the organisational level, clearer division of responsibilities is needed among central platform managers, local technical agencies, consultants, professional associations, and building owners. Central platform managers should maintain system standards, validation logic, and interoperability, while local technical agencies should provide technical review, applicant assistance, and local workflow monitoring. Consultants and professional associations can support applicants by preparing compliant technical documents, providing standardised guidance, and assisting with correction requests. This is aligned with engineering approval literature showing that building certification and permit processes require coordination among multiple departments, regulatory bodies, applicants, and technical professionals [4, 14, 18].

At the project level, management actions should focus on simplifying certification participation for building owners, especially for small and low-risk buildings. These actions may include standard technical document templates, pre-certification checklists, simplified procedures for small buildings, self-declaration mechanisms for low-risk cases, and standardised prototype designs. Such measures would reduce technical uncertainty, lower consultant dependence, and make the certification process more manageable for applicants. This is consistent with automated compliance checking literature, which suggests that digital systems should support guidance, pre-checking, and human expert oversight rather than rely entirely on fully autonomous compliance decisions [13, 16].

5.5 Theoretical Implications

Theoretically, this study retains the relevance of TPB and TAM while repositioning them within a building certification compliance context. The findings support TPB by confirming intention as the strongest behavioural driver of SLF certification participation, consistent with prior studies showing that intention plays a central role in compliance and technology-enabled behavioural outcomes [22–24]. The findings also extend TAM by showing that ease of use has a dual role: it strengthens intention and directly supports participation. In the context of SIMBG, ease of use should therefore be understood not only as a general technology acceptance factor, but also as a workflow-enabling condition that supports document submission, correction handling, and application monitoring.

The limited quantitative effect of technical and bureaucratic barriers suggests that the TPB construct of perceived behavioural control should be interpreted more carefully in digital building certification systems. Barriers may not always operate as direct statistical predictors of intention or participation, but may instead emerge through more specific workflow and institutional mechanisms. This interpretation is consistent with compliance studies showing that economic, institutional, and governance conditions can shape whether formal obligations are translated into actual compliance behaviour [25, 26]. In this study, the qualitative findings indicate that barriers may appear through consultant costs, weak document validation, repeated correction cycles, municipal interpretation differences,

limited technical staff capacity, and unclear responsibility among actors. Future models should therefore distinguish procedural, technical, financial, platform-related, and institutional barriers in digital building certification systems.

5.6 Limitations and Future Research

This study has several limitations. First, the quantitative sample was limited to three urban municipalities, namely Semarang, Sidoarjo, and Bandung, which have active SLF and SIMBG implementation contexts. Therefore, the findings should not be generalised to all regions of Indonesia, particularly rural municipalities, small districts, or areas with weaker digital infrastructure and lower administrative capacity. Although the three locations provide useful variation in urban certification practice, the study does not claim statistical representativeness at the national level. Future research should expand the sample to include rural areas, smaller municipalities, and regions with different levels of SIMBG maturity and SLF enforcement.

Another limitation concerns the measurement and interpretation of Public Participation (Y). Public Participation (Y) was originally measured using three indicators, but Y1, which captured prior SLF application or ownership, was excluded from the final measurement model because of its low loading. Therefore, the final construct should be interpreted based on the retained indicators, Y2 and Y3, which more directly reflect near-term participation intention and self-perceived capability to complete the SLF process. It does not fully capture actual historical SLF application behaviour or verified ownership of SLF. Future studies should incorporate administrative records, verified SLF ownership data, application records, or longitudinal tracking to distinguish between participation readiness and completed SLF certification behaviour.

6 Conclusion

This study examined the behavioural and system-level drivers of participation in Indonesia's SLF certification process through SIMBG. By repositioning SLF as a post-construction engineering compliance mechanism and SIMBG as a managed digital building certification workflow, the study extends the discussion beyond public participation and digital service adoption toward engineering compliance management. The findings show that SLF participation is shaped not only by awareness of regulatory obligations, but also by intention, platform usability, document readiness, actor coordination, and the ability of applicants to complete the certification workflow.

The quantitative findings indicate that intention is the strongest direct predictor of Public Participation, interpreted in the final model as respondents' readiness and perceived capability to proceed with SLF certification, while knowledge and ease of use significantly strengthen intention. Ease of use also directly supports participation, suggesting that SIMBG usability plays an important role in helping applicants navigate document submission, correction cycles, and application monitoring. Meanwhile, technical and bureaucratic barriers did not show statistically significant negative effects in the expected direction and should therefore be interpreted cautiously. However, the qualitative findings show that barriers remain important at the workflow level, particularly in relation to consultant costs, weak document validation, repeated corrections, inconsistent municipal interpretation, limited technical staff capacity, and unclear institutional responsibilities.

The theoretical contribution of this study lies in showing that digital building certification should be understood as a socio-technical engineering management process, not merely as an administrative platform or digital public service. The study connects behavioural intention, platform usability, regulatory knowledge, and workflow barriers within a single compliance management framework. In doing so, it demonstrates that certification participation depends on the interaction between users, technical documents, digital systems, consultants, and public agencies across the certification workflow.

In practice, the study shows that improving SLF compliance requires operational changes in the certification workflow. At the platform level, SIMBG should be strengthened through document pre-checking, mandatory field validation, cost and time estimation tools, and application progress tracking. At the organisational level, clearer responsibility-sharing is needed among central platform managers, local technical agencies, consultants, and professional associations. At the project level, standard technical templates, pre-certification checklists, simplified procedures for small buildings, and self-declaration mechanisms for low-risk cases could reduce the technical and financial burden faced by applicants.

Overall, this study demonstrates that low SLF participation should not be understood only as a problem of public awareness, individual intention, or bureaucratic complexity. It is also a digital certification workflow management issue involving technical validation, actor coordination, information flow, and institutional control. Strengthening SIMBG as a workflow control platform and improving coordination among technical actors are therefore essential for increasing building certification compliance, supporting safer building operation, and improving the effectiveness of post-construction regulatory management in Indonesia.

Author Contributions

Conceptualization, D.P.R. and A.R.T.; methodology, A.R.T. and D.P.R.; software, A.R.T.; validation, D.P.R., A.R.T., F.R.W., G.B.P., and S.A.; formal analysis, A.R.T.; investigation, D.P.R. and A.R.T.; resources, D.P.R. and D.S.; data curation, A.R.T. and D.P.R.; writing—original draft preparation, D.P.R. and A.R.T.; writing—review and editing, A.R.T., D.P.R., F.R.W., G.B.P., and S.A.; visualization, A.R.T.; supervision, D.P.R. and D.S.; project administration, D.P.R. and A.R.T. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

Declaration on the Use of Generative AI and AI-assisted Technologies

During the preparation of this manuscript, AI-assisted tools were used only to support language refinement, grammar correction, readability improvement, and editorial formatting. The tools were not used to generate research data, perform statistical analysis, make methodological decisions, or determine the interpretation of the findings. All content, data, analysis, citations, and conclusions were reviewed, verified, and approved by the authors, who remain fully responsible for the accuracy, originality, and integrity of the manuscript.

References

[1] J. Fauth, T. Bloch, and L. Soibelman, "Process model for international building permit benchmarking and a validation example using the Israeli building permit process," *Eng. Constr. Archit. Manag.*, vol. 31, no. 13, pp. 121–139, 2023. https://doi.org/10.1108/ECAM-06-2023-0593

[2] Á. Mena, F. López, J. M. Framiñan, F. Flores, and J. M. Gallego, "XPDRL project: Improving the project documentation quality in the Spanish architectural, engineering and construction sector," *Autom. Constr.*, vol. 19, no. 2, pp. 270–282, 2010. https://doi.org/10.1016/j.autcon.2009.10.001

[3] M. Ataide, O. Braholli, and D. Siegele, "Digital transformation of building permits: Current status, maturity, and future prospects," *Buildings*, vol. 13, no. 10, p. 2554, 2023. https://doi.org/10.3390/buildings13102554

[4] H. Urban, S. Fischer, and C. Schranz, "Adapting to an open BIM building permit process: A case study using the example of the City of Vienna," *Buildings*, vol. 14, no. 4, p. 1135, 2024. https://doi.org/10.3390/buildings14041135

[5] M. Gharbia, A. Chang-Richards, X. Xu, M. Höök, L. Stehn, R. Jähne, D. Hall, K. Park, J. Hong, and Y. Feng, "Building code compliance for off-site construction," *J. Leg. Aff. Dispute Resolut. Eng. Constr.*, vol. 15, no. 2, p. 04522056, 2023. https://doi.org/10.1061/JLADAH.LADR-856

[6] T. Antal and R. Számadó, "Design and evaluation of a compliance management framework for business operations: A system engineering perspective," *J. Eng. Manag. Syst. Eng.*, vol. 5, no. 2, pp. 120–136, 2026. https://doi.org/10.56578/jemse050201

[7] L. Amer, M. Thneibat, F. Sammour, and N. Lepkova, "Evaluating the e-permit system in construction using stakeholder analysis and network theory," *J. Civ. Eng. Manag.*, vol. 31, no. 3, pp. 224–247, 2025. https://doi.org/10.3846/jcem.2025.22253

[8] A. R. Thaha, E. Maulina, R. A. Muftiadi, and M. B. Alexandri, "TOE factors and value chain effects of e-business adoption on SMEs," *Uncertain Supply Chain Manag.*, vol. 10, no. 3, pp. 1029–1036, 2022. https://doi.org/10.5267/j.uscm.2022.2.009

[9] I. Ahmed, T. Gajendran, G. Brewer, K. Maund, J. von Meding, H. Kabir, M. Faruk, H. D. Shrestha, and N. Sitoula, "Opportunities and challenges of compliance to safe building codes: Bangladesh and Nepal," *APN Sci. Bull.*, vol. 9, no. 1, pp. 73–80, 2019. https://doi.org/10.30852/sb.2019.834

[10] J. Demuyakor, "Ghana's digitization initiatives: A survey of citizens' perceptions on the benefits and challenges to the utilization of digital governance services," *Int. J. Publ. Soc. Stud.*, vol. 6, no. 1, pp. 42–55, 2021. https://doi.org/10.18488/journal.135.2021.61.42.55

[11] E. Wihlborg, C. J. Sommar, A. Kulanovic, A. Kaharevic, and H. Iacobaeus, "Best practice of digital government in emerging democracies: Illustrations, challenges and reflections of state building processes," in *Proceedings*

of the 54th Hawaii International Conference on System Sciences, 2021, pp. 2133–2142. https://doi.org/10.24251/HICSS.2021.263

[12] S. Mukamurenzi, Å. Grönlund, and S. M. Islam, "Improving qualities of e-government services in Rwanda: A service provider perspective," *Electron. J. Inf. Syst. Dev. Ctries.*, vol. 85, no. 5, p. e12089, 2019. https://doi.org/10.1002/isd2.12089

[13] T. H. Beach, J. L. Hippolyte, and Y. Rezgui, "Towards the adoption of automated regulatory compliance checking in the built environment," *Autom. Constr.*, vol. 118, p. 103285, 2020. https://doi.org/10.1016/j.autcon.2020.103285

[14] V. Ciotta, A. Ciccone, D. Asprone, G. Manfredi, and E. Cosenza, "Structural e-permits: An openBIM, model-based procedure for permit applications pertaining to structural engineering," *J. Civ. Eng. Manag.*, vol. 27, no. 8, pp. 651–670, 2021. https://doi.org/10.3846/jcem.2021.15784

[15] C. R. Raitviir and I. Lill, "Conceptual framework of information flow synchronization throughout the building lifecycle," *Buildings*, vol. 14, no. 7, p. 2207, 2024. https://doi.org/10.3390/buildings14072207

[16] Y. Zou, B. H. W. Guo, E. Papadonikolaki, J. Dimyadi, and L. Hou, "Lessons learned on adopting automated compliance checking in the AEC industry: A global study," *J. Manag. Eng.*, vol. 39, no. 4, 2023. https://doi.org/10.1061/JMENEA.MEENG-5051

[17] A. Ivić, D. Stefanović, D. Dakić, T. Vučković, S. Havzi, and S. Sladojević, "Conceptual framework for the development of an e-government licensing system," *Access Sci. Bus. Innov. Digit. Econ.*, vol. 4, no. 2, pp. 313–330, 2023. https://doi.org/10.46656/access.2023.4.2(11)

[18] H. Olfat, B. Atazadeh, D. Shojaei, and A. Rajabifard, "The feasibility of a BIM-driven approach to support building subdivision workflows—Case study of Victoria, Australia," *ISPRS Int. J. Geo-Inf.*, vol. 8, no. 11, p. 499, 2019. https://doi.org/10.3390/ijgi8110499

[19] I. Ajzen, "The theory of planned behaviour," *Organ. Behav. Hum. Decis. Process.*, vol. 50, no. 2, pp. 179–211, 1991. https://doi.org/10.1016/0749-5978(91)90020-T

[20] M. Fishbein and I. Ajzen, *Predicting and Changing Behavior: The Reasoned Action Approach*, 1st ed. New York, NY, USA: Psychology Press, 2010.

[21] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Q.*, vol. 13, no. 3, pp. 319–340, 1989. https://doi.org/10.2307/249008

[22] T. Bani-Khalid, A. F. Alshira'h, and M. H. Alshirah, "Determinants of tax compliance intention among Jordanian SMEs: A focus on the theory of planned behavior," *Economies*, vol. 10, no. 2, p. 30, 2022. https://doi.org/10.3390/economies10020030

[23] M. D. Alam, A. W. Kusumadewi, and L. F. LH, "E-finance: What factors affect financial staff's motivation to utilize it?" *J. Akad. Akunt.*, vol. 7, no. 1, pp. 56–74, 2024. https://doi.org/10.22219/jaa.v7i1.31173

[24] A. Suryanto, N. Nurdin, A. Andriansyah, N. S. Rahayu, and E. Irawati, "Predicting supply chain management of e-waste recycling behavior using an extended theory of planned behavior model," *Uncertain Supply Chain Manag.*, vol. 11, no. 3, pp. 1001–1008, 2023. https://doi.org/10.5267/j.uscm.2023.4.022

[25] A. Sobhan, "Where institutional logics of corporate governance collide: Overstatement of compliance in a developing country, Bangladesh," *Corp. Gov. Int. Rev.*, vol. 24, no. 6, pp. 599–618, 2016. https://doi.org/10.1111/corg.12163

[26] D. Musimenta, S. K. Nkundabanyanga, M. Muhwezi, B. Akankunda, and I. Nalukenge, "Tax compliance of small and medium enterprises: A developing country perspective," *J. Financ. Regul. Compliance*, vol. 25, no. 2, pp. 149–175, 2017. https://doi.org/10.1108/JFRC-08-2016-0065