Operational Research in Engineering Sciences: Theory and Applications
Vol. 6, Issue 4, 2023, pp. 36-53
ISSN: 2620-1607
eISSN: 2620-1747
DOI: https://doi.org/10.31181/oresta/060403

SOFT SYSTEM METHODOLOGY FOR GREEN BUILDING DESIGN CONCEPTS FOR COMPLYING BUILDING REGULATION IN INDONESIA

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Received: 08 August 2023
Accepted: 14 September2023
First Online: 07 December2023

Research Paper

Abstract: *In order to adhere to the green building regulations established by the Minister of Public Works and Public Housing of the Republic of Indonesia, it is imperative to employ methods aimed at fostering awareness of the inherent advantages and positive effects associated with green buildings in the context of new construction. Unfortunately, the anticipated conversion of new construction projects into green buildings is not progressing as intended. Issues pertaining to planning, execution, utilization, and oversight, encompassing organizational considerations, financial aspects, and community engagement, have emerged as significant impediments. This situation perpetuates a misconception among the general public that investments in green building initiatives are prohibitively expensive. A primary challenge is the absence of explicit standards for green building investments, coupled with the inefficiency of gradually implementing reference terms within budgetary constraints. Previous research indicates that a holistic approach, aligning green building design with principles of sustainability and sustainable development, represents an optimal strategy to address these challenges. This work seeks to investigate how the principles of sustainable green building design can align with the requirements stipulated by the Minister and the Housing Regulation of the Republic of Indonesia. This endeavour involves integrating theoretical concepts with value engineering and life cycle cost assessment through the application of the soft system methodology in an action research framework. The outcome will be a theoretical framework that encapsulates initiatives, providing guidance for diverse strategies in green building practices that prioritize both sustainability and cost-effectiveness. The author underscores the importance of recognizing the dedication and knowledge required to comprehend that the expenses associated with constructing green buildings are outweighed by the substantial benefits achievable.*

Keywords*: Green Building, Cost Effectiveness and Efficiency, Lifecycle Cost Analysis, Soft System Methodology, Value Engineering.*

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1. Introduction

The promulgation of Republic of Indonesia Minister of Public Works and Public Housing Regulation (PUPR RI) Number 21 of 2021, pertaining to the Evaluation of Green Building Performance, delineates the criteria for mandatory compliance with green building standards for newly constructed edifices. This obligatory adherence applies to buildings falling within specific classifications, namely: a) Class 4 and 5 structures characterized by more than four floors and a minimum floor area of 50,000 m2; b) Class 6, 7, and 8 buildings exhibiting more than four floors and a minimum floor area of 5,000 m2; c) Class 9a constructions with an expansive area surpassing 20,000 m2; and d) Class 9b structures with a substantial area exceeding 10,000 m2 (Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia, 2021).

The Building Approval (PBG) is a governmental authorization granted to the proprietor or their designated representative, permitting the initiation of construction, renovation, maintenance, or modification activities for a building in accordance with predetermined specifications. The Certificate of Fitness for Occupancy (SLF) represents the evaluative procedure for newly completed structures. Notwithstanding the completion of construction, operational activities for any purpose are proscribed in the absence of an SLF, and the extension of the SLF is imperative to comply with green building requisites. In alignment with the GREENSHIP Rating Instruments instituted since 2009, the Green Building Council Indonesia (GBCI), a constituent of the World Green Building Council, has established the GREENSHIP certification system. This certification system is contingent upon the criteria devised by the World Green Building Council, wherein the primary objectives encompass environmental considerations (planet), societal factors (people), and economic facets (profit) in the pursuit of Sustainable Development Goals (Al-Ghamdi & Bilec, 2017).

Within the GREENSHIP framework, there exist six distinct categories, namely Suitable Site Development, Energy Efficiency & Preservation, Water Conservation, Materials Resources and Cycle, Indoor Health and Happiness, and Building Environment and Administration. Each of these categories encompasses three types of assessments, incorporating multiple criteria of diverse nature, as delineated by the Green Building Council Indonesia Version 1.2 (2014). The three assessment types are defined as follows: prerequisite criteria, which are obligatory criteria within each category that necessitate fulfilment before further evaluation; credit criteria, which are optional criteria within each category; and bonus criteria, which afford opportunities for earning additional points. Prerequisite criteria encompass fundamental requisites such as Water Calculation, OTTV Calculation, Basic Green Area, Water Metering, Electrical Sub-metering, Fundamental Refrigerant, Outdoor Air Introduction, and Basic Waste Management. Credit criteria span a wide array of considerations, including but not limited to site selection, community accessibility, public transportation, bike facilities, site landscaping, microclimate, storm water management, energy-saving policies, natural lighting, ventilation, global warming impact, water elimination strategies, water fixture efficiency, water recycling, rainwater harvesting, building and material recycling, eco-friendly materials, absence of Ozone Depleting Substances (ODP), use of prefabricated materials, utilization of regional materials, certified wood, CO2 monitoring, chemical pollution control, outdoor views, thermal comfort, visual comfort, acoustic levels, and basic waste disposal. Among the credit criteria that must be fulfilled are responsibilities such as serving as a Green Building Project Team Member, addressing Building Activity Pollution, implementing Advanced Waste Management, undertaking Appropriate Commissioning, submitting data for Green Building assessments, establishing Fit Out Agreements, and conducting Occupant Surveys. Bonus criteria include considerations related to On-Site Renewable Energy. The GREENSHIP certification system delineates four hierarchical levels, namely Platinum, Gold, Silver, and Bronze, reflecting varying degrees of achievement within the established criteria (GBCI, 2013).

In the period spanning from 2013 to 2018, Indonesia witnessed the certification of 20 buildings under the GREENSHIP program. This figure, albeit a noteworthy achievement, remains comparatively modest when juxtaposed against the broader spectrum of buildings within the country, particularly those surpassing 12 floors, numbering 1,329 in total. This scenario poses a substantial challenge, particularly in the conversion of conventional structures into green counterparts and the perpetuation of sustainability in extant green buildings. As per data from the GBCI until the year 2023, a mere 57 buildings have secured GREENSHIP certification. The restricted prevalence of green buildings can be ascribed, in large part, to the prevailing low awareness regarding the manifold benefits associated with the adoption of green building practices (Li et al., 2021). The majority of proprietors of buildings perceive investments in green building initiatives to be cost-prohibitive (Li et al., 2021). Furthermore, the operational and maintenance expenditures associated with green buildings are also regarded as elevated (Leskinen, Vimpari, & Junnila, 2020).

The challenges within the construction industry and the building sector contribute to the consumption of 36% of global energy and the emission of 39% of CO2 (Abergel et. al 2017). Green buildings with sustainable design yield 15% energy savings, 22.3% water savings, and 21% carbon reduction compared to conventional buildings (Ebrahim & Wayal, 2019). The differential in rental rates for green buildings, denoting a premium, spans between 5% and 10%, while cost performance falls within the range of 4.5% to 7% (Hwang, Zhu, Wang, & Cheong, 2017). An examination of Green Building standards in Poland revealed a noteworthy annual profit escalation of 26% (Plebankiewicz, Juszczyk, & Kozik, 2019). The optimization of building envelopes through the application of Value Engineering (VE) has yielded energy savings and enhanced lifecycle performance (Yuan et al., 2020). VE constitutes an approach directed at enhancing the functional performance of a building in correlation with the requisite resources for its attainment (Van Basten, Latief, & Berawi, 2019). Lifecycle Cost Analysis (LCCA) optimizes the selection of solutions by prioritizing those that yield the greatest financial benefits over their lifetime, emphasizing the lowest possible lifecycle cost. This approach serves as the primary objective in both technical and economic analyses (Marrana, Silvestre, de Brito, & Gomes, 2017).

SEM-PLS is employed to solve equation models with multiple dependent variables and recursive impacts. It relies on covariance evaluation, yielding a more dependable covariance matrix than linear regression analysis. SEM-PLS can be viewed as a combination of factorization and regression in simultaneously addressing multiple-level models that are not resolvable through linear regression equations (Aghili & Amirkhani, 2021). The Soft System Methodology (SSM) emerges as a viable approach for addressing intricate issues and serves as a pertinent methodology in facilitating the sustainable design of buildings. This methodology aims to attain economic value while adhering to the regulations outlined in Minister of PUPR RI Number 21 of 2021 (Saeedi, Mikaeili Tabrizi, Bahremand, & Salmanmahiny, 2022). In order to realize the envisioned design, a comprehensive literature review is conducted on key elements, including green building and the factors influencing it, with the aim of attaining cost-effectiveness and efficiency. Subsequently, the application of the soft system approach, coupled with value engineering and life cycle cost analysis, is employed in the design process (Niu, Lopez, & Cheng, 2011).

2. Literature Review

2.1. Green Building

A green building is characterized by a substantial commitment to energy, water, and resource conservation through the integration of environmentally sustainable building principles. It further ensures compliance with building technical standards corresponding to its classification and purpose at each phase of construction (Garzone, 2006; Lakhiar & Lakhiar, 2021).

2.2. Greenship

In the Indonesian context, GREENSHIP New Building represents a certification system designed for recently constructed and designed edifices. The "GREENSHIP" rating encompasses assessments of interiors, exteriors, dwellings, and surroundings for both newly developed and existing structures. Throughout the project lifecycle, spanning from the planning phase to construction, innovative approaches are employed by the project team to realize a fully operational green building and secure the associated certification (GBCI, 2013). The attainment of "GREENSHIP New Building Certification" can be realized through a two-phase process.

a. The highest possible Design Recognition (DR) result is 77 points.

The project committee obtains provisional certification based on the GREENSHIP evaluation tool during the final design and planning phases of the project, when the building is still in the planning stage.

b. An overall Final Assessment Stage (FA) result of 101 points

Employing the GREENSHIP evaluation methodology, the comprehensive performance of the building is assessed at its completion, considering both architectural and construction elements. The scores presented in Table 1 pertain to DR as well as FA.

Table 1: Rating Design Recognition (DR) (GBCI, 2013).

Rating	%	Minimum Score DR
Platinum	74	55
Gold	56	44
Silver	47	36
Bronze	36	28

2.3. Factors Affecting Green Building

To obtain the certification for a new GREENSHIP Building, there are six assessment categories with associated eligibility criteria. Each category comprises Bonus Points, Credit Points, and Prerequisites. The six categories are delineated as follows: Table 2 focuses on Appropriate Development on the site; Tables 3–7 address Energy Conservation and Efficiency; Table 5 pertains to Material Cycle and Resources; Table 6 is dedicated to Indoor Comfort and Health; and Table 7 encompasses Building and Environmental Management (GBCI, 2013; Zhao, Wang, Mbachu, & Liu, 2019).

Table 2: Appropriate Development in Site.

Aspects	Indicators	Point	Aspects	Indicators	Points
Plain Green Area	B 1,1	Perquisites	Essential Refrigerant	B 4.1	Perquisites
Bicycle Facility	B 1,2	2	Building and Material Reuse	B 4.2	2
Accessibility of Community	B 1,3	2	Certified Wood	B 4.3	2
Microclimate	B 1,4	2	Non ODS Usage	B 4.4	2
Public Transportation	B 1,5	2	Friendly Environmentally Material	B 4.5	3
Landscaping of Site	B 1,6	3	Material of Prefab	B 4.6	3
Selection of Site	B 1,7	3	Material of Regional	B 4.7	3
Management of Stormwater	B 1,8	3	Total in Categories		14
Total in Categories		17			

Table 3: Energy Conservation and Efficiency.

Aspects	Indicators	Point
Sub Metering of Electering	B 2.1.	Criterion
OTTV Calculation	B 2.2.	Criterion
Impact of Climate Change	B 2.3.	1
Measures of Energy Efficiency	B 2.4	20
Natural Lighting	B 2.5	4
On Site Renewable Energy	B 2.6	5 (Bonus)
Ventilation	B 2.7	1
Total in Categories		26

Table 4: Conservation of Water.

Aspects	Indicators	Points
Metering of Water	B 3.1.	Prerequisite
Calculation of water	B 3.2	Prerequisite
Alternative resources of Water	B 3.3.	2
Harvesting Rainwater	B 3.4.	3
Fixtures of water	B 3.5	3
Recycling of water	B 3.6	3
Reduction in Water usage	B 3.7	8
Landscaping Efficiency in water	B 3.8	2
Total in Categories		21

Table 5: Material Cycle and Resources.

Aspects	Indicators	Points
Essential Refrigerant	B 4.1	Perquisites
Building and Material Reuse	B 4.2	2
Certified Wood	B 4.3	2
Non ODS Usage	B 4.4	2
Friendly Environmentally Material	B 4.5	3
Material of Prefab	B 4.6	3
Material of Regional	B 4.7	3
Total in Categories		14
Aspects	Indicators	Points
Essential Refrigerant	B 4.1	Perquisites

Table 6: Indoor Comfort and Health.

Aspects	Indicators	Points
Outdoor Air Introduction	B 5.1	Prerequisite
Acoustic Level	B 5.2	1
CO_2 Monitoring	B 5.3	1
Chemical Pollutant	B 5.4	3
Environmental control of smoke of Tobacco	B 5.5	2
Outside View	B 5.6	1
Thermal Comfort	B 5.7	1
Visual Comfort	B 5.8	1
Total in Categories		10

Table 7: Environmental and Building Management.

Aspects	Indicators	Points
Basic Waste Management	B 6.1	Prerequisite
Advanced Waste Management	B 6.2	2
Construction Activity Pollution	B 6.3	2
GP Project Team Member	B 6.4	1
Proper Commissioning	B 6.5	3
Submission data of Green Building	B 6.6	2
Fit out Agreement	B 6.7	1
Survey of Occupier	B 6.8	1
Total in categories		13

2.4. Soft System Methodology

The objective of SSM is to leverage theoretical frameworks inherent in human activity systems to accommodate diverse perspectives. Subsequently, the selection of interventions for situational modification or resolution is guided by these models. SSM is specifically tailored to address unstructured or poorly organized problematic situations where stakeholders exhibit disagreement, extending even to the nature of the problem itself. This methodology proves highly beneficial in managing expectations, enforcing procedures, simulating prospective changes, and offering recommendations for improvements that align with the organizational context. Moreover, SSM is adept at highlighting numerous shortcomings in requirements management processes. While not all recommendations may be deemed indispensable, the instituted adjustments have demonstrably enhanced the organization's requirements engineering (Niu, Lopez, & Cheng, 2011). Peter Checkland originated SSM at Lancaster University in England in the 1960s. Initially conceived as a modelling technique for rendering complex issues more comprehensible, SSM's application has evolved over the years. It is now utilized not only for modelling but also as a tool for facilitating learning and fostering meaningful exercises in the realm of problem-solving.

The sequential phases of this model are delineated as follows:

(*1) Articulation of the problem situation in the form of an ongoing process.

(2) Rich Pictures provide a thorough comprehension of the pertinent issues, employing not only factual analysis but also cultural assessment. This cultural assessment encompasses an examination of the intervention, the social system (including how roles, norms, and values interact to structure the problematic situation), and the political framework (involving power structures and associated actions designed to accommodate diverse interests).

(3) The central objective of the activity system is articulated in the root description as a transformational process. This is elaborated by considering the mnemonic components CATWOE, which includes C (Consumers, representing the victims or beneficiaries of the transformation), A (Performers, individuals who may undergo role changes), T (Input to Output Transformation), W (Worldview, perspectives, and assumptions that confer significance to the change), O (Owner, the entity to whom the "system" reports and/or possesses the authority to impede change), and E (Environmental limitations, factors that influence the system but do not exert direct control over it).

(4) Constructing a conceptual framework for the root definition involves essential activities in evaluation and control to ensure the model aligns with the system concept. The inclusion of Efficacy (assessing the functionality of the means employed), Efficiency (quantifying the output relative to the resources expended), and Effectiveness (ascertaining whether the transformation aligns with long-term objectives) is imperative to substantiate this process.

(5) Conducting a comparative analysis between the model and the actual world involves assessing the congruence between depictions of real situations and the generated models (Sections 6 and 7). This phase allows for the identification of potential modifications and actions aimed at enhancing the problematic scenario. The conclusive step entails formulating recommendations for enhancements to the existing system.

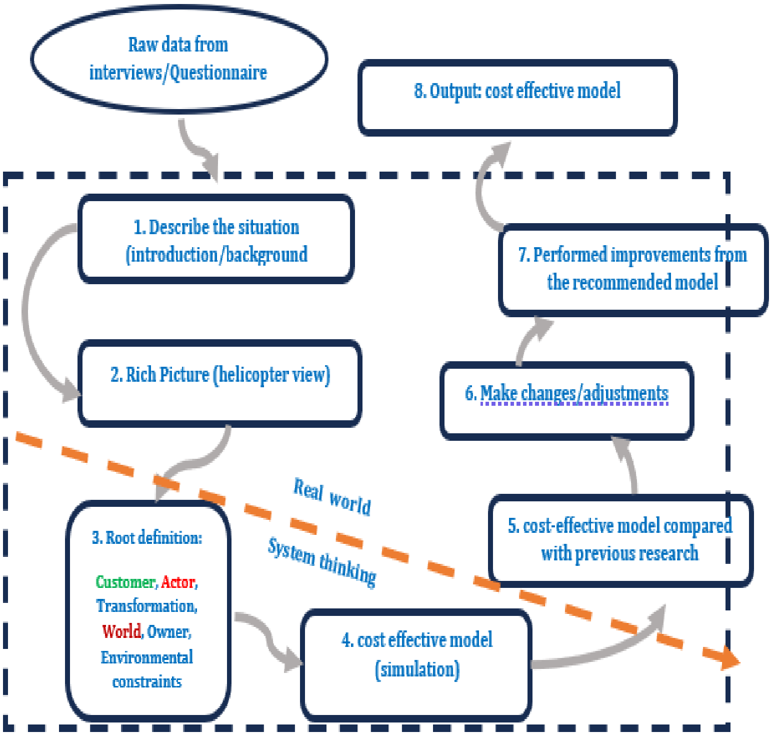


Figure 1: Steps of Soft System Methodology (Saeedi et al., 2022).

2.5. Value Engineering

VE involves the systematic scrutiny of projects, products, or processes by an impartial and multidisciplinary team of experts. The overarching objective is to enhance efficiency, effectiveness, and/or life cycle costs (Berawi, Miraj, Windrayani, & Berawi, 2019). Value engineering employs life cycle cost analysis grounded in the concept of value, leveraging this approach to identify the most economical alternatives (Husin, 2019; Imron & Husin, 2021).

The value engineering is a systematic approach overseeing the execution of work by interdisciplinary teams with the aim of augmenting project value through a thorough analysis of function-cost relationships (Delgado, Oyedele, Demian, & Beach, 2020). The procedural steps for Value Engineering activities encompass: 1) information gathering, 2) function analysis, 3) creativity and innovation, 4) development, 5) decision analysis, 6) decision-making, 7) implementation, 8) suggestion, and 9) research findings (Fan, Wei, Qian, & Chan, 2017). It is a structured process (Knowledge, 2007). Additionally, Al-Yousefi characterizes value engineering as a methodology that thoroughly contemplates changes to preclude undesired alterations (Janani, Chakravarthy, & Raj, 2018; Karamaşa et al., 2021).

2.6. Lifecycle Cost Analysis

The primary objectives of technical and economic analysis are the selection of solutions characterized by the most economical life cycle costs and overall profitability. Life Cycle Cost Analysis (LCCA) serves as an optimization technique to attain this goal (Marrana et al., 2017). The analytical approach of LCCA aids in identifying the most economically efficient solution that aligns with the project's objectives. It furnishes substantial information to inform the decision-making process comprehensively (Marrana et al., 2017). LCCA proves valuable in selecting the most cost-effective project among alternatives with differing initial and operational costs but similar performance objectives (Marrana et al., 2017). LCCA is a crucial tool for comparing initiatives with diverse starting and running costs but similar performance specifications to identify the most cost-effective project. The subsequent steps outline the general process for conducting LCC analysis:

1). Cost Breakdown Structure (CBS) - LCC Modeling without Residual Value - Life Cycle Cost Analysis - Sensitivity Analysis – Efficiency (Marrana et al., 2017).

2). Green buildings are accorded precedence throughout the entirety of the project life cycle, encompassing the manufacturing of building materials, their entire process, including the planning, designing, building, operating, maintaining, removing, and recycling of trash (Li et al., 2019).

3. Methodology

This literature review employs SSM to investigate green buildings, VE, and LCCA. Motivated by real-world problem-solving challenges faced by the Indonesian government in implementing Regulation of the Minister PUPR RI Number 21 of 2021, the focus is on activities necessary to transform or upgrade conventional buildings. The developed conceptual framework integrates SSM, green building, VE, and LCCA, incorporating multiple steps to address the prevailing issues (Latief et al., 2017). The research framework is presented in Table 8, delineated into two segments: problem-solving and research methodologies. This study will explicate the six steps outlined in Table 9, which constitute SSM-based activities. These stages include identifying unorganised difficulties, identifying problems, formulating root definitions that are connected to pertinent activity systems, developing conceptual models, juxtaposition of the theoretical framework with reality, and the systematic and culturally appropriate development of desirable interventions.

Table 8: Research Framework (Barton, Stephens, & Haslett, 2009).

Theoretical Framework	**Theoretical Framework**	**Based on Greenship there are six categories as factors and forty six (46) sub factors consisting of eight (8) prerequisites, thirty seven (37) criteria and one (1) bonus. There are eight (8) factors from value engineering, four (4) factors from lifecycle cost analysis and five (5) factors from green building development costs.**
Approaches for areas of interest in research	Research interest methodology	Utilising the Soft System Methodology for action research
Situation of Problematic	Real-world problematic situation	The identification of the problems found for this research are : 1) There is still low awareness of buildings owners about the enormous benefits of green buildings so that there are still few green buildings (Final, Featured, and Study 2023) 2) The majority of building owners have the opinion that green building invesment costs are expensive (Final, Featured and Study 2023) The problem formulatuon in this research was obtained as follows: a) What are the influential factors in obtaining a Greenship rating for multi-storey buildings? b) How to model the relationship between variabel that occur? c) How to produce cost effective green building construction on multi-story buildings?
Problem-solving Methodology	Methodology for problem-solving	Soft System Methodology action research
Area	The specific area in research	Forty two (42) buildings in Indonesia have obtained GREENSHIP Platinu, Gold, Silver or Bronze certification for design recognution

Table 9: Soft System Methodology stages (Barton, Stephens, & Haslett, 2009).

Phases of the system	**Picture**	**Collecting data method**
Initial Phase: Recognition of Unstructured Problem	Acquire a wide range of facts related to the challenging situation from sources of primary and secondary data. The results of the gathering and analysis provide a comprehensive understanding of the problem scenario within the study setting.	Literature study and initialinterview
Subsequent Phase: Systematizing the Problem	Systematically generate concepts pertaining to challenging circumstances derived from gathered data. The researcher elucidates the problem using a Rich Picture, transforming it into a structured illustration of the issue at hand	Structured and unstructured dialogue, analysis of written works, and comprehensive interviews
Third Phase: Crafting the Root Definition	Establish a metaphorical representation of the root problem that can address and elucidate systems within a research context. The Root Definition articulates what, how, and why of systems, contributing to a more comprehensive exploration of questions related to problematic situations.	Formal and informal discussion
Fourth Phase: Development of the Conceptual Model	Construct a Root Definition model grounded in CATWOE, and subject it to controlled analysis utilizing criteria of effectiveness and efficiency	Formal and informal discussion
Fifth Phase: Comparative Analysis of the Conceptual Model with the Real World	Compare the results of the study with real-world data using comparative tables specifically created to make the comparison process easier. The results of this comparison provide a basis for research to develop modifications intended for improving the troubling condition.	Formal and informal discussion
Sixth Phase: Methodical Advancement with Culturally Relevant Interventions	Examine and interpret problematic situations through the analysis of comparisons made. The outcomes of this analysis serve as the foundation for delineating discussions on changes pertaining to the problematic situations.	Formal and informal discussion

4. Results and Discussion

4.1 Unstructured Problems: Reality of Green Building in Indonesia

In the context of SSM-based action research focused on GBCI, an analysis reveals that from 2013 to 2018, only 20 buildings in Indonesia obtained GREENSHIP certification, a notably low figure compared to the total number of buildings, especially those exceeding 12 floors, which amounted to 1,329 structures. In discussions concerning the adoption of green building design principles, key stakeholders encompass government entities, specifically the Ministry of Public Works and Public Housing, and building proprietors. During this phase, a social analysis is conducted to discern elements. At the organizational level, there is a necessity for the Ministry of Public Works and Public Housing to enhance ministerial regulations. Additionally, a political analysis is undertaken to discern the aspirations and requirements of all stakeholders regarding the implementation of green building design principles. On an operational level, green buildings offer numerous advantages (Shen, Zhao, & Ge, 2020).

4.2 Organising Identified Issues: Rich Picture

The second phase of SSM-based action research involves structuring and simplifying the understanding of the identified problem. Figure 2 illustrates a Rich Picture, depicting the identified problems. In the realm of green building design, researchers scrutinized Ministerial Regulation No. 21 of 2021 from the Ministry of Public Works and Public Housing (PUPR) and regulations set by the Indonesian Green Building Council through GREENSHIP, both of which were applied during the design and construction phases. Problematic situations are discerned at the design and construction levels. At the design level, there are 6 categories, 8 prerequisites, 37 criteria, and 1 bonus. Each prerequisite, criterion, and bonus entails a cost impact in the form of additional investment costs. The implementation of construction stages also incurs a cost impact. However, during the operational stage, some savings can be realized, particularly in energy and water usage. As elucidated in previous research, considering feedback regarding design needs and demands from stakeholders leads to the development of an applicable design concept. (Wilson, 2001), that can influence the effectiveness (quality) of environmentally friendly structures and the productivity of their functioning.

4.3 Formula Root Defining: Implementing Green Environmental Design Approaches for GOS Management

The third step of SSM-Based Action Research focuses on the Root Definition at the organisational level, which emphasises adherence to laws and suggests the creation of operational instructions, pertaining to the adoption of green building design and construction concepts. The concept, aligned with the "Low Cost, Low Technology, Low Negative Impact Development" principle, aims to expedite the planning and construction of environmentally suitable and high-quality green buildings. The SSM-based action research approach was used to verify the preciseness of the Root Definition. This was done by CATWOE Analysis, as shown in Table 10. The examination covered, Transformation Process, Actors, Owner, and Environmental Constraints, Customers, and World View.

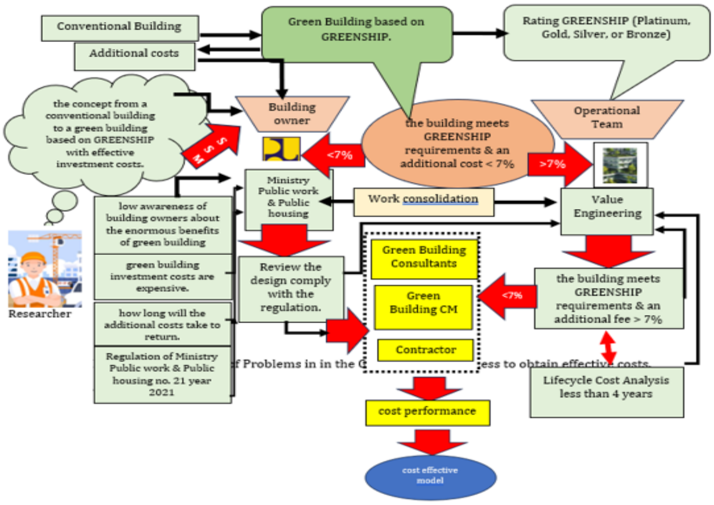


Figure 2: Rich Picture of Problems in in The Green Building Process to Obtain Effective Costs.

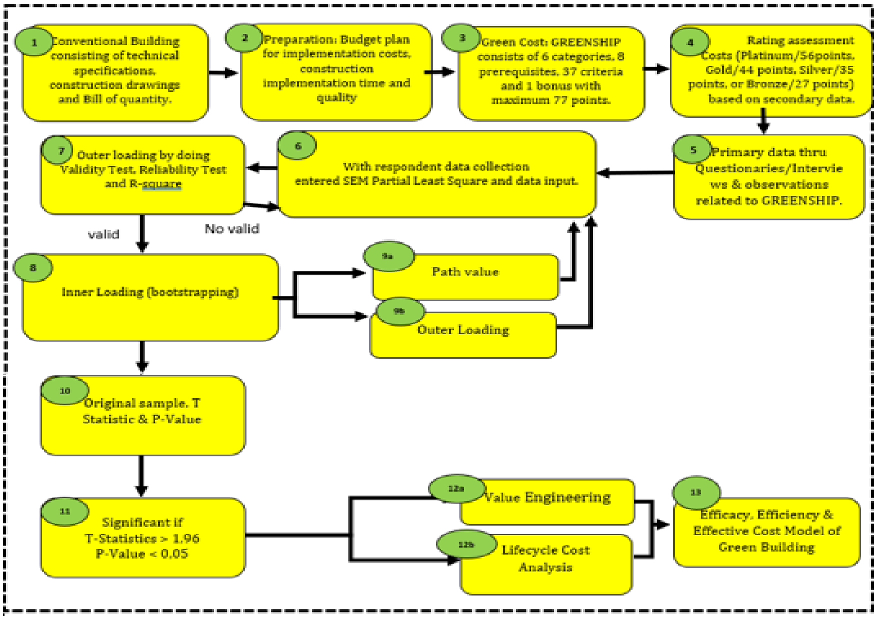


Figure 3: Conceptual Model for Explaining the concept of Green Building.

4.4 Developing a Conceptual Model

In the fourth phase of this study, researchers devised a conceptual model, illustrated in Figure 3. The conceptual model, crafted in this research, yields a cost-effective framework for design and construction in the context of implementing green building design concepts. It is constructed on the establishment of the fundamental concept developed in the previous phase and further fortified through extensive interviews with experts and consultants specializing in green building practices (Wong, 2019).

The description of the conceptual model commences with outlining a series of activities essential for formulating technical guidelines. Through these activities, the aspiration is to develop an optimal form of technical implementation aligned with the principles of green building design. The aim is that the availability of this guide will enhance the cost-effectiveness and efficiency of green building performance. Consequently, coordinated efforts are imperative to generate technical implementation instructions pertaining to green building design and construction. Figure 2 furnishes an overview of the conceptual model, illustrating the interconnection of each activity, the relationships between these activities, and their impact on the design and construction of the implemented activities. The conceptual testing of the model encompasses five performance criteria: ethicality, elegance, effectiveness, efficiency and efficacy (Wilson, 2001). The rationale for the selection of these criteria is explicated in Table 11.

Table: 10. CATWOE analysis (Yuslim, Simanjuntak, & Lianto, 2023).

Customer Actor	Emd users, consultans, and contractors building owners
Transformation	Transforming ineffective and inefficient costs into efficient and effective outcomes through the application of value engineering and life cycle cost analysis
World	The application of SEM-PLS with variable green building, value engineering and lifecycle cost analysis
Owner	Building owner
Environment	Regulations, financial resources, temporal considerations, Green ship design principles, stakeholder requirements, and environmental factor

Table 11: Testing Criteria with 3 E (Mourtzis, Fotia, & Doukas, 2015).

Efficacy	The existence of the Regulations of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 21 of 2021 about green building
Efficiency	Optimal utilization of resources, with a particular emphasis on financial considerations
Effective	The model's success is contingent on the precise execution of Green ship design concepts and the steadfast adherence to Green ship principles throughout the construction phase

Under this conceptual framework, organisational recommendations entail compliance with Regulation No. 21 of 2021 issued by the Minister of Public Works and Public Housing of the Republic of Indonesia and the Indonesian Green Building Council Regulations with GREENSHIP as a foundation for executing green building design and construction concepts. Enhancements are introduced by delineating the scope of work that has not been detailed in various stages of green building management.

1. The planning phase, incorporating essential principles aligned with the utilisation of green building design principles and the consideration of what stakeholders want provide helpful insights for the development of technical standards.
2. The technical design phase encompasses considerations that necessitate parties to serve as a reference
3. The construction phases of a green building encompass the requisites for seamless development
4. In the utilization and maintenance phase, the scenario is distinctly outlined and contingent upon the three preceding stages.

4.5 Comparing Conceptual Models with the Real World

Each of the five phases of SSM-based investigation involve participating in debates to compare and contrast the idea model with the perceived actuality. At this stage, researchers devise change initiatives or action steps necessary to address problems. From a philosophical perspective, various considerations must be taken into account when implementing the concept of green building design and construction:

1. Expedite the execution of Republic of Indonesia Minister of Public Works and Public Housing Regulation No. 21 of 2021 pertaining to green buildings
2. Conducting awareness campaigns regarding the GREENSHIP green building rating regulations established by the Green Building Council Indonesia
3. Enhance collaboration with stakeholders concerning the formulation of guidelines for green building design and construction.

4.6 Key elements of the recommendations that impact the effective and efficient design and construction of green buildings.

The sixth phase of SSM-based action research involves crafting suggestions for changes in actions required to address the problem. These recommendations are usually outlined in a methodical and culturally favourable way to promote the intended change of a problem scenario that initially arose as a research inquiry. These actions are considered methodical and culturally suitable in terms of the effectiveness and efficiency of managing environmentally friendly structures, as outlined in Table 12.

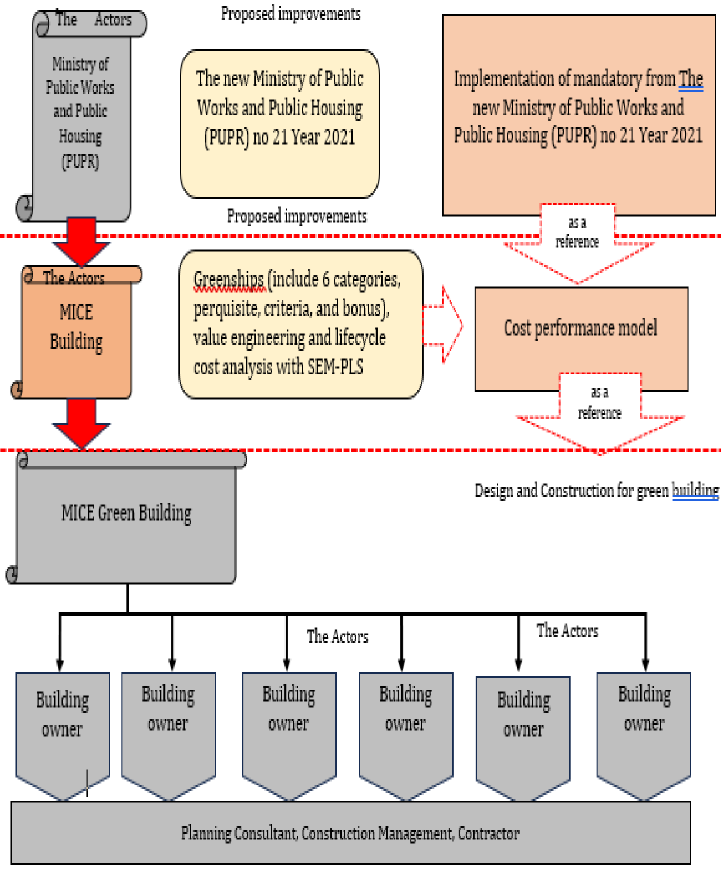


Figure 4: Role of the Each Department of Green Building.

Table 12: Key elements of Recommendations (Wilson, 2001).

Root Definition	Systematically desirable	Culturally Feasible	Recommendation
Defining Green Building Design Concepts with effective and efficient cost	Yes, the explanation of the green building design concept in design and construction is needed that make it easier for consultants and contractors to plan and implement green building work so that it runs efficiently and effectively. In its execution, it necessitates reinforcement through governmental regulations serving as a legal foundation.	Yes, there are no detailed guidelines that guide stakeholders involved in green building design and construction.	Research on green building design and construction, guided by green ship principles established by the Green Building Council Indonesia, with the aim of achieving cost-effectiveness in building green structures, particularly in compliance with the obligatory Republic of Indonesia Minister of Public Works and Public Housing Regulation No. 21 of 2021

5. Implications and Future Directions

The review study underscores implications for the context of the green building concept in Indonesia. Limited adoption of green building certifications, with only 20 GREENSHIP certified buildings out of 1,329 between 2013 and 2018, reveals a gap in environmental sustainability initiatives. Problems identified in design and construction stages, portrayed in the Rich Picture, highlight the complexity and cost impacts of implementing green building concepts. Recommendations stress the need for accelerated regulatory compliance, increased GREENSHIP regulations awareness, and enhanced coordination for guideline preparation. These implications collectively emphasize the necessity for joint efforts from government and industry stakeholders to streamline green building practices, improve regulatory compliance, and foster a more sustainable approach to construction and design in Indonesia. The study also serves as a resource for policymakers and authorities, emphasizing the importance of green building. Additionally, it provides a foundation for further research in this area to enrich the existing body of knowledge.

While the study has significant implications, there are some limitations that could be addressed in future research to enhance generalizability. Firstly, the study is limited to the period of 2013 to 2018, indicating a need for ongoing monitoring in the future to explore trends in green building. Additionally, the study focuses on GREENSHIP certified buildings, and a more comprehensive analysis of various green building certification systems could provide a more nuanced understanding of the industry landscape. Moreover, the research heavily relies on government regulations and the GREENSHIP certification framework, potentially neglecting other factors influencing green building practices. Future research could involve a more extensive examination of stakeholder perspectives, encompassing architects, builders, and occupants, for a holistic view of challenges and opportunities. Investigating the long-term performance and operational efficiency of certified green buildings could offer valuable insights into their sustainability impact. Finally, exploring the integration of emerging technologies and innovations in the green building sector could pave the way for more advanced and sustainable practices in the future. Further research could also adopt both quantitative and qualitative approaches, strengthening the relationship by adopting a mixed-methods approach to increase research generalizability.

6. Conclusion

The SSM-based action research in Indonesia highlights industry challenges and opportunities. The study indicates a low adoption of GREENSHIP certification from 2013 to 2018, underscoring the necessity for enhanced efforts in promoting sustainable building practices. Additionally, the paper discusses the causes of ineffective and inefficient green building design and construction, attributing them to the lack of technical guidelines referencing sustainable green building design concepts. Failure to incorporate the sustainability principles of green building design in the planning and design phases may lead to increased maintenance costs. This research endeavours to elucidate the significance of technical guidelines at the organizational level. Ultimately, the Rich Picture and conceptual model developed in the study discern and highlight key issues in the design and construction stages, with a specific emphasis on the cost implications associated with green building initiatives.

7. Suggestions

The implementation of Regulation No. 21 of 2021 on green buildings in Indonesia necessitates the adherence to green building standards for new constructions. The research findings highlight numerous benefits for stakeholders in green building initiatives. It is crucial for these advantages to extend to other buildings, gaining support from all stakeholders and fostering a collective commitment. Legislative bodies should consider revising existing rules to address issues hindering the adoption of green buildings. Promoting a culture of environmental responsibility requires heightened awareness through extensive campaigns and educational initiatives. Enhanced collaboration among government entities, industry experts, and certifying bodies is vital for the effective implementation and enforcement of green building regulations. Financial incentives or subsidies can catalyse greater adoption by alleviating initial financial concerns. Additionally, continuous research and monitoring programs are essential to track the progress of green building practices and inform flexible policies that accommodate new developments and technological advancements in the construction sector.

References

Aghili, N., & Amirkhani, M. (2021). SEM-PLS approach to green building. Encyclopedia, 1(2), 472-481. https://doi.org/10.3390/encyclopedia1020039

Al-Ghamdi, S. G., & Bilec, M. M. (2017). Green building rating systems and whole-building life cycle assessment: Comparative study of the existing assessment tools. Journal of Architectural Engineering, 23(1), 04016015. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000222

Barton, J., Stephens, J., & Haslett, T. (2009). Action research: its foundations in open systems thinking and relationship to the scientific method. Systemic Practice and Action Research, 22(6), 475-488. https://doi.org/10.1007/s11213-009-9148-6

Berawi, M. A., Miraj, P., Windrayani, R., & Berawi, A. R. B. (2019). Stakeholders' perspectives on green building rating: A case study in Indonesia. Heliyon, 5(3), e01328. https://doi.org/10.1016/j.heliyon.2019.e01328

Delgado, J. M. D., Oyedele, L., Demian, P., & Beach, T. (2020). A research agenda for augmented and virtual reality in architecture, engineering and construction. *Advanced Engineering Informatics, 45*, 101122.

Ebrahim, A., & Wayal, A. S. (2019). BIM Based Building Performance Analysis of a Green Office Building. International Journal of Scientific & Technology Research, 8(8), 566-573. http://dx.doi.org/10.1007/978-981-13-8507-0_28

Fan, K., Wei, G., Qian, Q., & Chan, E. (2017). Costs and Benefits of Implementing Green Building Policy. In Proceedings of the World Sustainable Built Environment Conference (WSBE17). Construction Industry Council. http://resolver.tudelft.nl/uuid:b53bb0bc-a7a7-4aee-b93b-0520b9213a2e

Garzone, C. (2006). U.S. Green Building Council and the Leed™ Green Building Rating System. U.S. Green Building Council. https://www.academia.edu/2460927

GBCI. (2013). Greenship Untuk Bangunan Baru Versi 1.2. Green Building Council Indonesia. https://gbcindonesia.org/files/resource/9b552832-b500-4b73-8c0eacfaa1434731/Summary%20GREENSHIP%20New%20Building%20V1.2.pdf

Husin, A. E. (2019). Implementation Value Engineering In Diaphragm Wall at High Rise Building. International Journal of Scientific Research Engineering & Technology, 8(1), 16-23. https://karyailmiah1.mercubuana.ac.id/wp-content/uploads/2019/03/Implementation-Value-Engineering-In-Diaphragm-Wall-at-High-Rise-Building.pdf

Hwang, B.-G., Zhu, L., Wang, Y., & Cheong, X. (2017). Green building construction projects in Singapore: Cost premiums and cost performance. Project Management Journal, 48(4), 67-79. https://doi.org/10.1177/875697281704800406

Imron, A., & Husin, A. E. (2021). Value engineering and lifecycle cost analysis to improve cost performance in green hospital project. Archives of Civil Engineering, 67(4), 497-510. https://doi.org/10.24425/ace.2021.138514

Janani, R., Chakravarthy, P. K., & Raj, D. R. R. (2018). A study on value engineering & green building in residential construction. International Journal of Civil Engineering and Technology, 9(1), 900-907. http://iaeme.com/Home/issue/IJCIET?Volume=9&Issue=1

Karamaşa, Ç., Ergün, M., Gülcan, B., Korucuk, S., Memiş, S., & Vojinović, D. (2021). Ranking value-creating green approach practices and choosing ideal green marketing strategy for logistics companies. Operational Research in Engineering Sciences: Theory and Applications, 4(3), 21-38. https://doi.org/10.31181/ORESTA20402021K.

Lakhiar, M. T., & Lakhiar, M. T. (2021). Occupational Health and Safety Performance in High-rise Building Projects in Pakistan: A Systematic Literature Review. Operational Research in Engineering Sciences: Theory and Applications, 4(1), 99-114. http://dx.doi.org/10.31181/oresta2040199l

Latief, Y., Berawi, M. A., Basten, V., Budiman, R., & Riswanto, R. (2017). Premium Cost Optimization of Operational and Maintenance of Green Building in Indonesia Using Life Cycle Assessment Method. AIP Conference Proceedings, 1855(1), 020007. https://doi.org/10.1063/1.4985452

Leskinen, N., Vimpari, J., & Junnila, S. (2020). A review of the impact of green building certification on the cash flows and values of commercial properties. Sustainability, 12(7), 2729. https://doi.org/10.3390/su12072729

Li, Y., Song, H., Sang, P., Chen, P.-H., & Liu, X. (2019). Review of Critical Success Factors (CSFs) for green building projects. Building and Environment, 158, 182-191. https://doi.org/10.1016/j.buildenv.2019.05.020

Li, Y., Rong, Y., Ahmad, U. M., Wang, X., Zuo, J., & Mao, G. (2021). A comprehensive review on green buildings research: bibliometric analysis during 1998–2018. *Environmental Science and Pollution Research, 28*, 46196-46214.

Marrana, T. C., Silvestre, J. D., de Brito, J., & Gomes, R. (2017). Lifecycle cost analysis of flat roofs of buildings. Journal of Construction Engineering and Management, 143(6), 04017014. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001290

Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia. (2021). Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia Nomor 9. https://jdih.pu.go.id/detail-dokumen/2882/1

Mourtzis, D., Fotia, S., & Doukas, M. (2015). Performance Indicators for the Evaluation of Product-Service Systems Design: A Review. In S. Umeda, M. Nakano, H. Mizuyama, H. Hibino, D. Kiritsis, & G. von Cieminski (Eds.), Advances in Production Management Systems: Innovative Production Management Towards Sustainable Growth (pp. 592-601). Springer International Publishing. https://doi.org/10.1007/978-3-319-22759-7_68

Niu, N., Lopez, A. Y., & Cheng, J.-R. (2011). Using soft systems methodology to improve requirements practices: an exploratory case study. IET Software, 5(6), 487-495. https://doi.org/10.1049/iet-sen.2010.0096

Plebankiewicz, E., Juszczyk, M., & Kozik, R. (2019). Trends, costs, and benefits of green certification of office buildings: a Polish perspective. Sustainability, 11(8), 2359. https://doi.org/10.3390/su11082359

Saeedi, I., Mikaeili Tabrizi, A. R., Bahremand, A., & Salmanmahiny, A. (2022). A soft systems methodology and interpretive structural modeling framework for Green infrastructure development to control runoff in Tehran metropolis. Natural Resource Modeling, 35(2), e12339. https://doi.org/10.1111/nrm.12339

Shen, C., Zhao, K., & Ge, J. (2020). An overview of the green building performance database. Journal of Engineering, 2020, 3780595. https://doi.org/10.1155/2020/3780595

Van Basten, I. C., Latief, Y., & Berawi, M. A. (2019). Conceptual development of cost benefit analysis based on regional, knowledge, and economic aspects of green building. Civil Engineering, 10(1), 81-93. https://doi.org/10.14716/ijtech.v10i1.1791

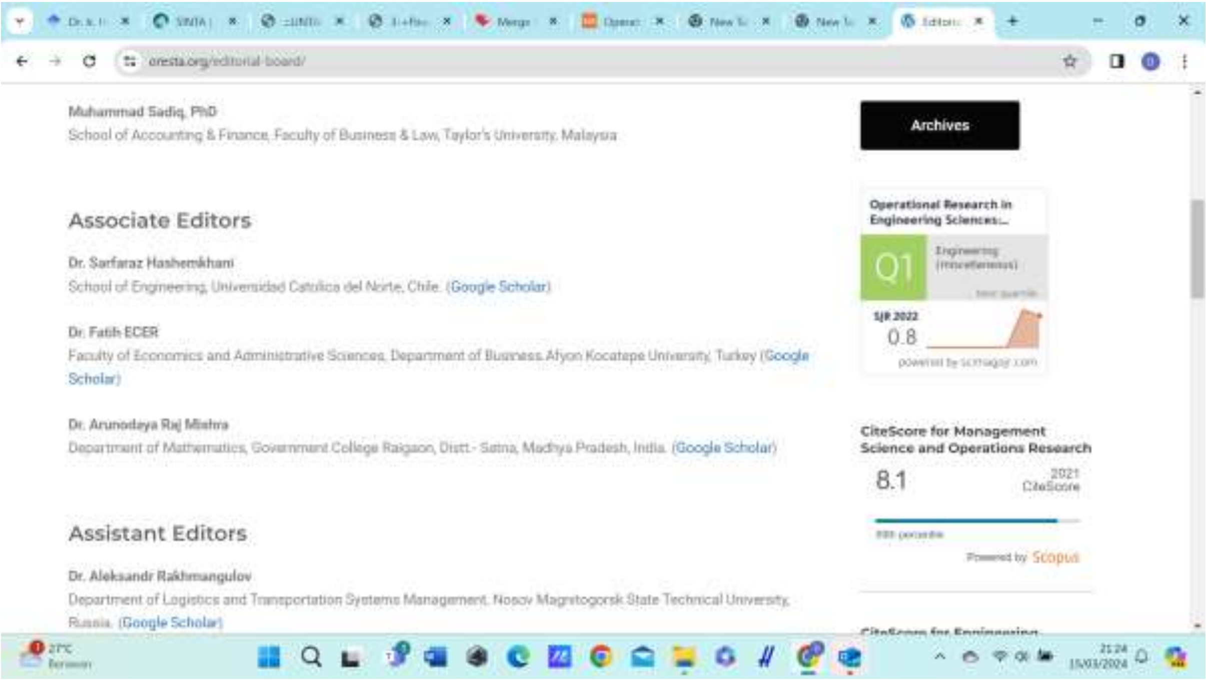
Wilson, B. (2001). Soft Systems Methodology: Conceptual Model Building and Its Contribution. John Wiley & Sons.

Wong, K. K.-K. (2019). Mastering partial least squares structural equation modeling (PLS-Sem) with Smartpls in 38 Hours. IUniverse. https://www.indigo.ca/en-ca/mastering-partial-least-squares-structural-equation-modeling-pls-sem-with-smartpls-in-38-hours/9781532066498.html

Yuan, Z., Zhou, J., Qiao, Y., Zhang, Y., Liu, D., & Zhu, H. (2020). BIM-VE-based optimization of green building envelope from the perspective of both energy saving and life cycle cost. Sustainability, 12(19), 7862. https://doi.org/10.3390/su12197862

Yuslim, S., Simanjuntak, M. R. A., & Lianto, F. (2023). Variables and Indicators to Measure The Performance of Sustainable Construction Project Management of City Park. Planning Malaysia, 21(25), 329-345. https://doi.org/10.21837/pm.v21i25.1242

Zhao, L., Wang, B., Mbachu, J., & Liu, Z. (2019). New Zealand building project cost and its influential factors: A structural equation modelling approach. Advances in Civil Engineering, 2019, 1362730. https://doi.org/10.1155/2019/1362730



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