

A conceptual green IT implementation maturity model for organizational information systems development: Measurement instrument and improvement roadmap

Uky Yudatama^{1*} and Rofi Abul Hasani¹

¹ Universitas Muhammadiyah Magelang, Magelang, Indonesia

*Corresponding author's email: uky@unimma.ac.id

Abstract

Organizations are increasingly required to implement environmentally responsible practices, including in the management of information systems. However, many organizations lack standardized tools to measure their current Green IT implementation maturity or plan structured improvements. This study aims to develop a maturity model, design a reliable and valid measurement instrument, and construct improvement roadmaps to guide organizations toward sustainable IT practices. Using a mixed-methods approach combining literature review, expert interviews, and survey-based data analysis, this research identifies five key dimensions of Green IT maturity: governance, policies and procedures, ICT asset management, integration into business processes, and pro-environmental culture. The resulting measurement demonstrates high reliability and construct validity and enables classification of organizations into maturity levels. Practical roadmaps are provided to help organizations advance from lower to higher maturity stages. The findings contribute to a robust tool for regular assessment and strategic planning of Green IT practices.

Keywords

Green IT, Maturity model, Measurement instrument, Sustainability, Organizational information systems

Introduction

Environmental degradation and climate change have increased pressure on organizations to adopt sustainable practices, including in information technology (IT). Green IT promotes environmentally responsible practices throughout the IT lifecycle, from procurement and operation to disposal [1], [2]. Regulatory bodies, customers, and investors increasingly expect organizations to integrate sustainability into IT governance and operations [3].

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However, many organizations lack structured methods to assess their current Green IT maturity and identify systematic improvement steps [4]. Without clear measurement tools and maturity benchmarks, Green IT initiatives often remain fragmented and difficult to evaluate.

Previous studies have explored Green IT from various perspectives, including conceptual frameworks, best practices, energy-efficient computing, green data centers, and policy development [5]–[8]. While these studies provide valuable insights, most focus on specific aspects and do not offer an integrated and empirically validated maturity model [9]. Moreover, limited research translates maturity assessment into actionable improvement roadmaps that support organizational progression [10].

To address this gap, this study develops and validates a comprehensive Green IT implementation maturity model applicable across industries and organizational contexts. The model integrates five dimensions: governance; policies and procedures; ICT asset management; integration into business processes; and pro-environmental culture. A measurement instrument was developed using a Likert scale and empirically tested through Exploratory and Confirmatory Factor Analysis.

This study is designed to achieve three primary objectives. First, it seeks to develop and empirically validate a comprehensive Green IT maturity model that captures the essential dimensions of sustainable IT implementation. Second, the study constructs a reliable and statistically tested assessment instrument that enables organizations to measure their current level of Green IT maturity. Third, it formulates structured improvement roadmaps tailored to different maturity levels, providing systematic guidance for organizational progression. By offering a validated diagnostic framework combined with practical implementation guidance, this research supports organizations in embedding sustainability principles into their IT strategies in a structured and measurable manner.

In terms of academic contribution, this study advances Green IT research by proposing an integrated and multi-dimensional maturity model that combines governance, operational, and cultural aspects within a unified framework. The study further strengthens its contribution through empirical validation of the measurement instrument using factor analysis techniques. In addition, it introduces a maturity classification system that enables benchmarking and performance comparison across organizations. Finally, it provides structured and actionable improvement roadmaps, ensuring that the proposed model functions not only as an assessment tool but also as a strategic guide for implementation. Compared to prior conceptual or sector-specific models, this study offers a validated and operationalized framework that supports cross-industry application and strategic decision-making.

Method

This research adopts a mixed-methods approach to develop, validate, and apply a Green IT implementation maturity model, along with a measurement instrument and practical improvement roadmap. The methodology was designed to ensure both theoretical grounding and empirical rigor, involving multiple stages of qualitative and quantitative data collection and analysis. The research process was conducted in a sequential manner as follows, as shown in [Figure 1](#).

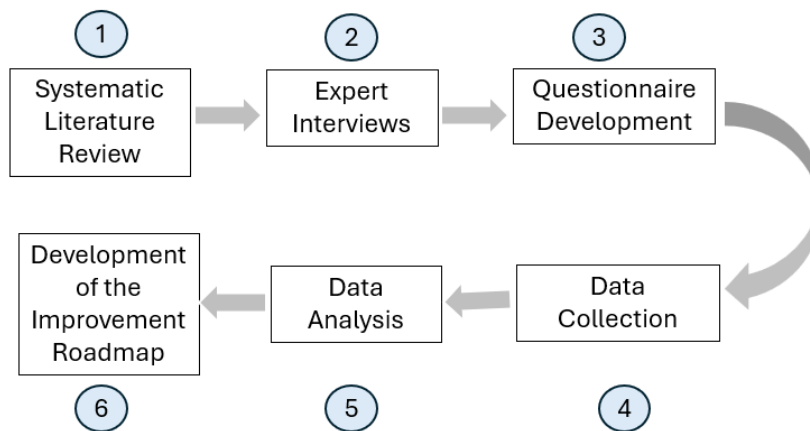


Figure 1. Flowchart of the Green IT Maturity Model Development Process

Systematic literature review

The first stage involved a systematic literature review to identify the key dimensions and indicators of Green IT implementation from previous studies. Academic journal articles, conference papers, and review articles focusing on Green IT, sustainability in information systems, IT governance, and organizational maturity models were analyzed. The review aimed to extract common themes and conceptual frameworks that could inform the development of the initial model.

Expert interviews

Following the literature review, semi-structured interviews were conducted with selected experts in the areas of Green IT, IT governance, and sustainability management. This phase aimed to validate and refine the initial set of Green IT dimensions and indicators identified from the literature. In addition, the interviews provided practical insights into implementation challenges, organizational constraints, and best practices in Green IT adoption.

A total of five experts participated in this stage. The participants were selected using purposive sampling to ensure relevant expertise and experience. The selection criteria included: (1) a minimum of five years of professional experience in IT governance or sustainability management; (2) direct involvement in organizational policy development or IT strategic planning; and (3) demonstrated knowledge or practical engagement in Green IT or environmental management systems. This selection strategy strengthened both the conceptual robustness and the practical relevance of the proposed maturity dimensions.

Questionnaire development

Based on the validated dimensions and indicators, a questionnaire was developed to assess the maturity level of Green IT practices within organizations. The questionnaire employed a 5-point Likert scale to measure the level of implementation, integration, and policy existence for each indicator. Items were designed to be simple, clear, and applicable across both public and private sector organizations.

Data collection

The finalized questionnaire was distributed to organizations across multiple sectors, including government agencies, educational institutions, and private companies. The survey targeted respondents who were directly involved in IT management or sustainability initiatives, such as IT managers, sustainability officers, and organizational decision-makers with comprehensive knowledge of IT operations.

Purposive sampling was employed to ensure that participants possessed relevant experience and insight into Green IT implementation within their organizations. Data were collected through both online and offline channels over a defined period to maximize coverage and enhance response diversity. A total of 150 valid responses were obtained and included in the analysis.

The sample size meets commonly accepted methodological standards for factor analysis. Established guidelines recommend a minimum ratio of 5–10 respondents per measurement item to achieve statistical adequacy and stable factor structures. Considering the number of indicators developed in this study, the final sample exceeds this threshold, thereby supporting the robustness and reliability of the Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) procedures.

Data analysis

Data analysis was conducted in two main phases to ensure the validity and reliability of the proposed measurement instrument. First, Exploratory Factor Analysis (EFA) was performed to identify the underlying factor structure of the questionnaire and to examine whether the measurement indicators clustered into coherent dimensions as initially hypothesized. This step aimed to explore the dimensionality of the construct and refine the grouping of items based on empirical evidence.

Subsequently, Confirmatory Factor Analysis (CFA) was conducted to validate the proposed factor structure and to assess the construct validity of the measurement model. The CFA procedure included evaluation of overall model fit, examination of factor loadings, and assessment of internal consistency using reliability indicators such as Cronbach's alpha.

Both analyses were performed using standard statistical software. Only items that met acceptable thresholds for reliability and validity were retained in the final version of the measurement instrument, ensuring the robustness and empirical soundness of the model.

Development of the improvement roadmap

Based on the maturity levels identified from the survey results, a structured improvement roadmap was formulated. This roadmap provides step-by-step guidance for organizations to progress from one maturity level to the next. The roadmap was designed by synthesizing input from the expert interviews, literature findings, and real-world organizational practices.

This structured and integrative methodology ensures that the resulting maturity model and instrument are not only theoretically sound but also practical, applicable, and capable of guiding organizations in the systematic implementation and improvement of Green IT practices.

Results

This study produced three main outputs: a Green IT maturity model, a validated measurement instrument, and structured improvement roadmaps. Each result aligns chronologically with the stages outlined in the methodology section.

Green IT maturity dimensions identified

Based on literature review and expert validation, the study successfully identified five key dimensions of Green IT maturity that represent the core components required for organizational sustainability in IT operations:

1. Governance: Establishment of clear Green IT roles and structures.
2. Policies & procedures: Existence of formal regulations on energy saving and procurement.
3. Green ICT asset management: Responsible lifecycle management of IT assets.
4. Integration into business processes: Embedding Green IT into operations and planning.
5. Pro environmental culture & behavior: Employee awareness and behavior toward sustainability.

Measurement instrument validation

A Likert-scale questionnaire was developed to measure the maturity of each dimension. After distribution to multiple organizations, statistical analysis was conducted:

1. Exploratory Factor Analysis (EFA) showed that all items clustered into their intended dimensions.
2. Confirmatory Factor Analysis (CFA) confirmed the structural validity of the model, with goodness-of-fit indices within acceptable thresholds.
3. Reliability tests (e.g., Cronbach's Alpha > 0.7) confirm internal consistency across all dimensions.

Maturity level classification

Using the instrument, organizations were classified into five maturity levels (Initial, Developing, Defined, Managed, and Optimized). Each level reflected a progressive integration of Green IT, from awareness to full strategic alignment.

Development of improvement roadmaps

Customized roadmaps were formulated to help organizations progress from one maturity level to the next. For example:

1. From initial to developing: Establish governance and formalize Green IT policies.
2. From developing to defined: Integrate Green IT metrics into business planning.
3. From defined to optimized: Implement green innovations such as virtualization and green cloud services.

These roadmaps provide practical, actionable steps for different organizational contexts.

Discussion

The findings of this study confirm that a structured approach to Green IT implementation is both measurable and actionable [11]. The five identified dimensions are consistent with established theories in organizational change, sustainability management, and IT governance. However, this study extends prior work by providing an empirically validated measurement instrument and structured implementation guidance [12], [13].

Compared to earlier studies that primarily offered conceptual models or focused on isolated aspects such as energy efficiency or asset disposal, this research proposes a more holistic and empirically supported framework [14]. While some existing frameworks emphasize policy development, they often overlook behavioral dimensions or lack validated assessment tools [15]. The inclusion of pro-environmental culture as a core dimension represents an important advancement, underscoring the role of human and organizational factors in achieving sustainable IT practices [16].

The classification of organizations into distinct maturity levels enables benchmarking and systematic progress tracking features that are frequently absent in previous approaches [17]. Furthermore, the development of structured improvement roadmaps enhances the practical value of the model, ensuring that it serves not only as a diagnostic tool but also as a prescriptive guide for organizational transformation [18].

The results also indicate that many organizations remain at early stages of Green IT maturity. This condition may be influenced by limited sustainability awareness, weak regulatory enforcement, resource constraints, or the absence of structured assessment mechanisms [19]. By offering measurement clarity and strategic direction, the proposed model helps decision-makers implement Green IT initiatives in a more systematic and coordinated manner.

Nevertheless, several limitations should be acknowledged. Although the sample included organizations from multiple sectors, certain industries were more represented than others, which may introduce sectoral bias. In addition, data were collected within a limited geographic scope, potentially affecting the generalizability of the findings to organizations operating under different regulatory, economic, or cultural environments. Variations in environmental regulations, government incentives, and sustainability culture across countries may influence the trajectory of Green IT maturity development.

The practical application of the model may also encounter contextual challenges. Organizations operating in environments with weak environmental governance may lack sufficient regulatory pressure to formalize Green IT initiatives. Cultural differences in leadership style, organizational hierarchy, and employee engagement can affect the effectiveness of governance mechanisms. Moreover, industries heavily dependent on legacy systems or with low digital readiness may face technical and financial barriers when implementing advanced green innovations such as virtualization, cloud migration, or carbon-aware IT operations.

Future research should therefore conduct cross-country validation, sector-specific adaptation, and integration with established sustainability and IT governance standards to enhance external validity and practical scalability [20].

In conclusion, this study offers a scientifically grounded and practically applicable framework for the systematic implementation of Green IT. By bridging theoretical constructs with actionable guidance, it contributes to the advancement of sustainable information systems and supports organizations in achieving measurable and long-term IT sustainability.

Conclusion

This study addresses the growing need for a structured and measurable approach to Green IT implementation within organizational information systems. In line with the research objectives, the study successfully develops a comprehensive Green IT maturity model, a reliable measurement instrument, and practical improvement roadmaps that support systematic and sustainable IT management [21].

The findings demonstrate that Green IT implementation can be meaningfully assessed through five interrelated dimensions: governance, policies and procedures, ICT asset management, integration into business processes, and pro-environmental culture and behavior. The validated measurement instrument enables organizations to identify their current maturity level and understand the key areas requiring improvement [22]. More importantly, the proposed maturity levels and corresponding roadmaps translate assessment outcomes into actionable strategies, bridging the gap between evaluation and implementation.

From a broader perspective, this research contributes to the field of information systems and sustainability by providing an empirically grounded framework that integrates technical, organizational, and behavioral aspects of Green IT [23]. Unlike prior approaches that emphasize isolated practices or conceptual discussions, this work advances current knowledge by offering a unified and applicable model that supports continuous improvement and strategic decision-making [24].

Future research may extend this study by applying the model across different countries and industrial sectors to enhance its generalizability. Further integration with established sustainability and IT governance standards may also strengthen its practical adoption and impact. Through these extensions, the proposed model can continue to evolve as a valuable reference for advancing sustainable information systems practices [25].

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References

1. S. Murugesan, "Harnessing Green IT: Principles and practices," *IT Professional*, vol. 10, no. 1, pp. 24–33, 2008.
2. M. Molla, S. Pittayachawan, B. Corbitt, and D. Deng, "An international survey on green IT: What practices and technologies do organizations implement?" *Communications of the ACM*, vol. 54, no. 12, pp. 118–123, 2011.
3. R. Harmon and N. Auseklis, "Sustainable IT services: Assessing the impact of green computing practices," in *PICMET '09*, Portland, OR, 2009, pp. 1707–1717.
4. J. Dedrick, "Green IS: Concepts and issues for information systems research," *Communications of the Association for Information Systems*, vol. 27, pp. 173–184, 2010.
5. T. B. Hilty and B. Aebischer, "ICT for sustainability: An emerging research field," in *ICT Innovations for Sustainability*, AISC, vol. 310, Springer, 2015, pp. 3–36.
6. A. Pradhan and C. Mbohwa, "Development of biofuels in South Africa: Challenges and opportunities," *Renewable and Sustainable Energy Reviews*, vol. 39, pp. 1089–1100, 2014.
7. M. M. Hasan, A. S. A. Alshammari, and H. R. Motahari-Nezhad, "A maturity model for green IT: A case study of a telecommunications company," *Sustainable Computing: Informatics and Systems*, vol. 28, p. 100406, 2020.
8. J. vom Brocke, S. Seidel, and J. Recker, "Green business process management: Towards the sustainable enterprise," *Business Process Management Journal*, vol. 18, no. 5, pp. 698–714, 2012.
9. A. S. Abubakar, S. Behraves, S. Rezapouraghdam, and S. Y. Y. Tanova, "Applying Green IT maturity model in developing countries: Challenges and opportunities," *Technological Forecasting and Social Change*, vol. 172, p. 121012, 2021.
10. P. S. Johnson and G. J. Smith, "Measuring Green IT: Developing and validating a measurement instrument," *Journal of Cleaner Production*, vol. 235, pp. 878–889, 2019.

11. S. Murugesan and G. Gangadharan, "Harnessing Green IT: Principles, practices, and technologies," Wiley Encyclopedia of Computer Science and Engineering, pp. 1–13, 2009.
12. J. Kotter, *Leading Change*. Boston, MA, USA: Harvard Business School Press, 1996.
13. P. Weill and J. W. Ross, *IT Governance: How Top Performers Manage IT Decision Rights for Superior Results*. Boston, MA, USA: Harvard Business School Press, 2004.
14. J. Dedrick, "Green IS: Concepts and issues for information systems research," *Communications of the Association for Information Systems*, vol. 27, pp. 173–184, 2010.
15. S. Seidel, J. Recker, and J. vom Brocke, "Sensemaking and sustainable practicing: Functional affordances of information systems in green transformations," *MIS Quarterly*, vol. 37, no. 4, pp. 1275–1299, 2013.
16. A. Bandura, "Social cognitive theory of organizational management," *Academy of Management Review*, vol. 14, no. 3, pp. 361–384, 1989.
17. M. Becker, R. Knackstedt, and J. Pöppelbuß, "Developing maturity models for IT management," *Business & Information Systems Engineering*, vol. 1, no. 3, pp. 213–222, 2009.
18. R. P. Bostrom and J. S. Heinen, "MIS problems and failures: A socio-technical perspective," *MIS Quarterly*, vol. 1, no. 3, pp. 17–32, 1977.
19. A. S. Abubakar, S. Behraves, S. Rezapouraghdam, and S. Y. Y. Tanova, "Applying Green IT maturity model in developing countries: Challenges and opportunities," *Technological Forecasting and Social Change*, vol. 172, p. 121012, 2021.
20. International Organization for Standardization, *ISO 14001:2015 Environmental Management Systems Requirements with Guidance for Use*. Geneva, Switzerland: ISO, 2015.
21. S. S. Gupta, M. Molla, and A. Chaudhuri, "IT eco-sustainability and the greening of enterprise IT: A strategic framework," *Information Systems Frontiers*, vol. 18, no. 2, pp. 293–314, 2016.
22. A. M. Gholami, S. Watson, M. Hasan, and R. Moeini, "Green IT adoption: A motivational perspective," *Decision Support Systems*, vol. 56, pp. 93–102, 2013.
23. S. Malhotra, A. Grover, and S. Singh, "Green IT: An empirical study of awareness and adoption in developing countries," *Journal of Global Information Technology Management*, vol. 24, no. 3, pp. 189–210, 2021.
24. D. R. Chen, P. Preston, and J. Swinkels, "A framework for assessing Green IT maturity in public sector organizations," *Government Information Quarterly*, vol. 36, no. 4, p. 101395, 2019.
25. K. S. Hasan and S. H. Rahman, "Integrating ISO 14001 environmental management systems with IT governance frameworks: A Green IT perspective," *International Journal of Information Management*, vol. 44, pp. 141–151, 2019.