Journal of Information Technology Management

Print ISSN: 2008-5893

Online ISSN: 2423-5059

A Fuzzy Inference System to Evaluate Maturity of Green Information Technology

Ameneh Khadivar*

*Corresponding author, Associate prof., Department of Social Science and Economics, Alzahra Univerity, Tehran, Iran. E-mail: a_khadivar@yahoo.com

Maryam Mobini Kashe

MSc., Department of Social Science and Economics, Alzahra Univerity, Tehran, Iran. E-mail: mobini412@gmail.com

Raha Basraei

MSc. Student, Department of Social Science and Economics, Alzahra University, Tehran, Iran. E-mail: rbasraei@gmail.com

Abstract

Green information technology is in the spotlight for organizations, helping them save money by using information technology (IT) to achieve the highest efficiency and thus reduce environmental impacts. One of the ways that can help organizations planning for deploying green IT is to evaluate green information technology maturity (GITM). Previous studies have referred to various criteria for green IT evaluation, most of which are qualitative criteria that are difficult to measure and evaluate in ambiguous conditions. The main objective of this study is to identify crucial criteria that affect the GITM level and to design a fuzzy inference system to assess the GITM level in any organization. While using a Mamdani Inference system, inputs can be verbal expressions or crisp values, and the output shows the level of maturity of green information technology. Since green IT knowledge is not modeled in previous studies, modeling it in the current study is a valuable step for organizations confused about various factors they should consider for going green. The main system criteria are the conditions of the data center, office environment, work practice, procurement, and corporate citizenship. Due to the generality of the model used for the knowledge base system development, organizations can use this system for the green IT maturity level determination. The presented inference system helps organizations understand their status of being IT green

and plan for the following steps to accomplish their desired maturity level. The proposed inference system has been tested, validated, and used to determine the maturity level of Tehran municipality.

Keywords: Green Information Technology, Green IT Maturity, Maturity Evaluation, Fuzzy Inference System

Journal of Information Technology Management, 2024, Vol. 16, Issue 2, pp. 1-15
Published by the University of Tehran, College of Management
doi: https://doi.org/ 10.22059/JITM.2023.306213.2567
Article Type: Research Paper

Received: February 12, 2023
Received in revised form: January 11, 2024
Accepted: February 28, 2024
Published online: April 30, 2024

Introduction

Climate change is a global issue, but still, there is not enough information and knowledge to predict its effects. The essential responses of all sectors in every corner of the world should be expressed as a strategy so that it can reduce the adverse effects of climate change on the way to its use and achieve economic growth. The IT sector is no exception to this and can play a role in making the economy greener. Green IT affects technology, competitive strategy, and even business strategic opportunities. As a result, the perception and influence of green IT are critical to continue business progress (Molla, 2008). Nowadays, one of the vital objectives decision-makers consider for improving organizational sustainability is an effective strategy for green IT implementation (Asadi et al., 2021). Since technology is a key reason for environmental issues and a lifesaving solution maker (Imasiku et al., 2019), focusing on IT to improve sustainability is suitable. The organization's information resources are one of the primary sources of greenhouse gas emissions and an essential solution for reducing carbon and green management. Hence, green information systems are a critical zone to consider for improving an organization’s sustainability along with decreasing carbon footprints (Singh & Sahu, 2020). Information technology provides many opportunities for organizations to save money or increase revenue. As a part of a strategic effort to reduce energy consumption and greenhouse gas emissions, organizations should be actively compatible with green IT (Ateetanan & Usanavasin, 2015). Various factors affect IT managers’ green IT insights and how they plan or utilize green IT practices (Anthony et al., 2020). However, recognizing their current GITM level is the first step organizations can take before developing strategies for improving their green IT status to achieve the goal of green management effectively. The presented models in the organization's GITM evaluation context can help organizations recognize their green IT maturity level to implement decisions and actions for investment in IT (Khadivar & Abdian, 2018). Examining the mentioned models shows that most of the variables affecting the GITM are qualitative and ambiguous, and their accurate evaluation is difficult. Since greenness is a complex gray concept, determining the exact boundary for the organization's maturity in this area is troublesome. As a result, researchers considered using methods that can model the GITM concept; in this regard, this study aims to design and implement a fuzzy inference system to evaluate an organization's GITM level and determine it with a fuzzy approach. One of the sub-goals that developing such a system will achieve is the multiple usage possibilities of engineered knowledge in the expert system in different organizations with a self-assessment approach that reduces the need for access and advice from experts in the field of green IT.

Green Information Technology

Most developed countries have been concerned with environmental deterioration and how it shapes their economies and policies (Ramayah et al., 2010). Practitioners have begun to focus on green IT, but there is still little research in this area (Khadivar & Dortaj, 2021). While green IT has different meanings, a simple and comprehensive definition would be applying green insights into the IT industry (Jayaprakash & Pillai, 2020). In other words, it refers to the use of IT resources efficiently (Akman & Mishra, 2015). GIT even considers the manufacturing side of the IT industry, meaning organizations ensure the use of green insights in IT gadget production (Ojo & Fauzi, 2020). It is defined from the perspective of the supply chain to the green supply chain, which refers to the integration of environmental thinking in product design, production, storage, distribution, and management of End-of-life (EOL) products in the supply chain (Molla, 2009; Molla et al., 2009). It can be called the umbrella, which refers to information systems, eco-friendly methods, and applications and includes three complementary approaches to empowering IT to improve environmental sustainability. Green IT system has the capacity not only to help minimize energy accepted manuscript consumption of organizations and mines (Chilamkurti et al., 2009; Kusi-Sarpong et al., 2016) but also support in mitigating the overall environmental impact significantly (Bhadauria et al., 2014; Ryoo & Koo, 2013). The dimensions of green IT include its policy usage, IT usage for supporting ecological sustainability, and green awareness creation (Muladi & Surendro, 2014). Despite various definitions of green IT, it is still a vague term. To reduce this ambiguity, identifying green information systems can help (Ijab et al., 2010). The purpose of using green IT is to reduce the overall environmental impacts of information and communication technology by adopting criteria such as taking ecological approaches for the production and use of IT equipment and facilities to optimize the use of information and communication technology equipment throughout the network infrastructure to reduce energy consumption (Jenkin et al., 2011). Many developing countries are moving towards the principles of using green IT. The time has come for these countries to perform green IT and take advantage of its implementation (Srivastava & Srivastava, 2012). People should consider the three dimensions of economy, technology, and process in green IT implementation. In corporate decision-making and financial profit, the economic side is one of the first considerations. The green IT technology dimension supports hardware, software, network infrastructure, applications, data center management, and cloud computing. The process dimension refers to eco-friendly processes, reducing carbon emissions and increasing customer satisfaction, and ultimately, the most complicated side, the people dimension, indicates changes in human resources (Muladi & Surendro, 2014). Researchers divided the incentives for green IT implementation into two categories: economic, regulatory, and ethical motivations in the first group and forced and arbitrary motives in the second group (Nazari & Karim, 2012). One of the critical issues that organizations need to consider is identifying the contributing factors to the success or failure of green IT implementation projects. One of the vital factors for a green IT project's success is working in the existing global standards framework for minimizing power and energy usage along with implementing alternative methods for cooling data centers (Velte et al., 2008). Nowadays, using green information technology is essential. Organizations seek green IT projects for various reasons, including lower power consumption, lower costs, lower carbon emissions, less environmental impact, improved system performance, increased collaboration and interactions, space storage, and agile workforces (Akman & Mishra, 2015).

Green Information Technology Maturity

The GITM model evaluates the various aspects of an organization's operations, behaviors, and achievements. To have a complete and comprehensive report, the model carefully analyzes the multiple functions within an organization, and each unit is examined separately. Groups typically integrated with the maturity model include data centers, end-user computing, asset life cycle, IT service management, and people's activities (Desai & Bhatia, 2011). As yet, several models have been presented in the field of GITM by researchers, such as the GITM model by Desai et al. (2011), the maturity framework for sustainable ICT management by Donnellan et al. (2011), and SURF GITM model, a maturity model based on the views and ideas of experts among employed people, presented by Henkel et al. (2014), are valid models for introducing green information maturity (Desai & Bhatia, 2011; Donnellan et al., 2011; and Hankel et al., 2014).

Evaluation of Green Information Technology Maturity

Organizations can use GITM assessment as a tool for evaluating their GITM rating and determining their maturity extent in green IT, along with steps they should take to reach the optimal maturity level and the techniques and processes they can use. Ateetanan et al. (2015), in their research, presented a model for assessing the level of GITM in Thailand that integrates the e-mobility maturity model of greenhouse technology for determining the readiness of green IT in Thailand's public sector (Ateetanan & Usanavasin, 2015). This model reflects the specific IT terms in the public sector and includes 42 indicators in 5 areas of a data center, office environment, work practice, procurement, and corporate citizenship. Desai and Bhatia (2011) introduce a GITM model for evaluating and implementing green IT services. Organizations can use this model to estimate and rank their maturity in green matters and organizational efforts for a greener future. This model focuses on the role of IT in organizations, regardless of the scope of the industry (Desai & Bhatia, 2011). The study by Lunardi et al. (2013) develops a tool that assesses GITM and identifies the primary activities adopted and the various components affecting organizations in determining environmental sustainability in the information technology field. The proposed framework in this study describes four structures for assessing GITM. These indicators are social awareness of the organization, IT sustainable measures, IT activities monitoring, and the search and updating of approaches related to its use (Lunardi et al., 2013). Park et al. (2010) analyzed Korea's green IT environment followed by steps for a green IT maturity assessment program. After analyzing the credibility of Korean green IT, experts evaluated 64 useful indicators for GITM evaluation. They defined six maturity stages (from zero to five) for each indicator and examined their weights based on relative importance. According to the GITM assessment, 64 indicators were identified in five areas: data center (15 indicators), office environment (15 indicators), work practice (16 indicators), procurement (9 indicators), corporate citizenship (9 indicators), which were considered as criteria affecting organization GITM for design and development of the fuzzy inference system (Mobinikeshe et al., 2017; and Park et al., 2012).

Fuzzy Inference System

Fuzzy inference systems are newer versions of the expert systems that use fuzzy logic to process. They integrate membership functions and use fuzzy rule sets (Matthews, 2003). The fuzzy inference is the most critical phase of the fuzzy inference system processing and is carried out according to the rules. Since fuzzy inference systems provide a systematic process to convert a knowledge base into a nonlinear mapping, they are used in engineering applications and decision-making (Dalvand et al., 2022).

Methodology

The present study is an applied development in goals and descriptive in terms of data. Also, its designed strategy is the case study. To design a fuzzy inference system for evaluating the green IT maturity level, researchers used library research for rule production, which the experts validated for the designed inference system. This study uses the judgmental sampling. Finally, the number of experts in the sample is six people. We considered one of the areas of the Tehran municipality as the case study, in which six experts have entered the information in the system for self-assessment of the organization. According to the other research and models, this study uses the model and metrics of Park et al. (2010) as the basis. This model has been surveyed in more than 300 companies from different industries in Korea, and one of its strengths is the lack of dependency on the specific sector (Park et al., 2012), in which maturity in various areas is measured with each other. Therefore, the resulting fuzzy inference system will have this advantage as well. This model has a standard questionnaire cited in various studies. Accordingly, its validity is confirmed. With these descriptions, Table 1 shows the research criteria, and Table 2 indicates the GITM-level definitions.

Table 1

Research Criteria

Sub-Subcategories	**Sub-Categories**	**Major Criteria**
Basic application of server virtualization solutions	Physical Equipment	Data Center
Use of orchestration tools		
Optimized use of server instances		
Practice of intelligent refreshing		
Server performance and power efficiency		
Storage integration	Server Assets	
Management of storage equipment usage indicators		
Network convergence		
Management of intelligent power allocation		
Single platform integration of backup SW		
Sub-Subcategories	**Sub-Categories**	
Real-time monitoring of power consumption	Support Infrastructure	
Efficient lighting design		
Energy-efficient DC		
Automated temperature and moisture control		
DC rationalization program in place		
Screensavers disabled	PC	Office Environment
Power control by an IT device power management system		
Desktops replaced by laptop computers		
Use of thin client solutions		
Power shut off for unused IT devices		
Use of multifunction printing devices	Printers	
Use of virtual fax services		
Use of toner-saving solutions		
Automatic power shut-off for night hours and weekends		
Integrated print management service		
A wireless network instead of a fixed-line network	Office Equipment	
Intelligent lighting system		
Energy-efficient lighting system		
Automatic office temperature control		
Power shut off for display screens during night hours and weekends		
Work processes performed electronically	Applications	Work Practice
Electronic approval system		
Electronic settlement/payment processing with customers and business partners		
Implementation of an Internet-based sales channel		
Electronically-issued customer invoices		
Application rationalization		
Process streamlining and improvement		
Use of integrated communications tools		
Use of video conference systems	Operation	

Telework/mobile office support		
Support for and encouragement of telecommuting		
Green IT education provided to staff regularly	Management	
Environmental impact analysis		
Cost charge-back system for IT services		
Mechanism of charging back carbon costs to units/sections and projects		
Efficient IT asset replacement cycle/lifecycle	Asset Management	Procurement
CMDB management		
CMDB linked with service catalogs		
Use of certified energy-efficient IT devices/equipment	Capital Costs	
Carbon emissions considered when purchasing new assets		
The existence of a policy/rule requiring the use of products compliant with environmental regulations		
Use of smart logistics systems	Operating Costs	
Minimization of the use of consumables		
Use of environment-friendly office supply products encouraged		
Management of toxic or hazardous substances on items sold or discarded	Waste Disposal	Corporate Citizenship
Incentives offered to staff for waste reduction		
Waste audits and efforts to minimize environmental impact		
Re-use of wastewater and waste heat		
Existence of a program encouraging staff participation in environmental movements	Waste Reduction	Corporate Citizenship
Use of smart redundancy		
Electronic distribution of customer/vendor brochures		
Rules requiring the re-use of assets	Recycling	
Re-use of consumables		

Table 2

Definition of Green IT Maturity Levels (Park et al., 2012)

Green Maturity Level	Green Maturity Level Number	Process
Incomplete	0	Although a process is in place, it is not used, and efforts to draw actual benefits from it are insufficient.
Initial	1	The process is not at all or poorly documented and tends to be modified depending on the user or event.
Repeatable	2	Although the process manual or instructions are far from clear or complete, they, nevertheless, help maintain existing practices.
Defined	3	A clearly established process exists, and the process has improved over time.
Managed	4	The process is carried out using statistical, quantitative techniques, and it is possible to predict quantitative. values.
Optimized	5	There is a quantitative process improvement goal, and the process has been continuously improved to reflect the business goals.

Designing a Fuzzy Inference System

At this stage, according to the identified criteria and sub-criteria through the standard questionnaire and the literature review, researchers designed two expert systems. They used a single-layer inference system with 64 criteria as input for the second inference system. The first inference system includes five separate subsystems for the five main criteria. The main variables for each subsystem are sub-criteria of the main ones. The output of each subsystem is an input for the first inference system. Accordingly, the result of the inference system is the ultimate score for the organization's GITM. Table 3 presents the organization's score and mapping green IT maturity level. Since the first inference system consists of subsystems, it is a hybrid inference system. It can be advantageous for organizations that cannot identify all essential criteria and sub-criteria for score evaluation. Figure 1 shows the research conceptual model or the research hybrid model architecture, and Figure 2 displays the single-layer inference system's architecture.

Figure 1

Conceptual Model of Research (Hybrid System Architectures

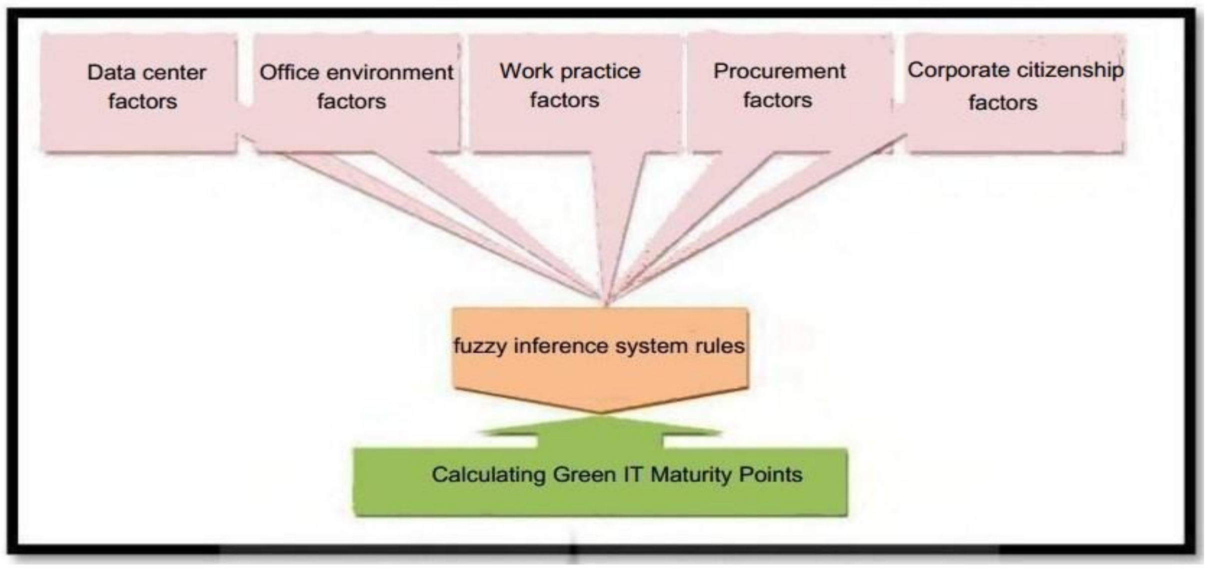
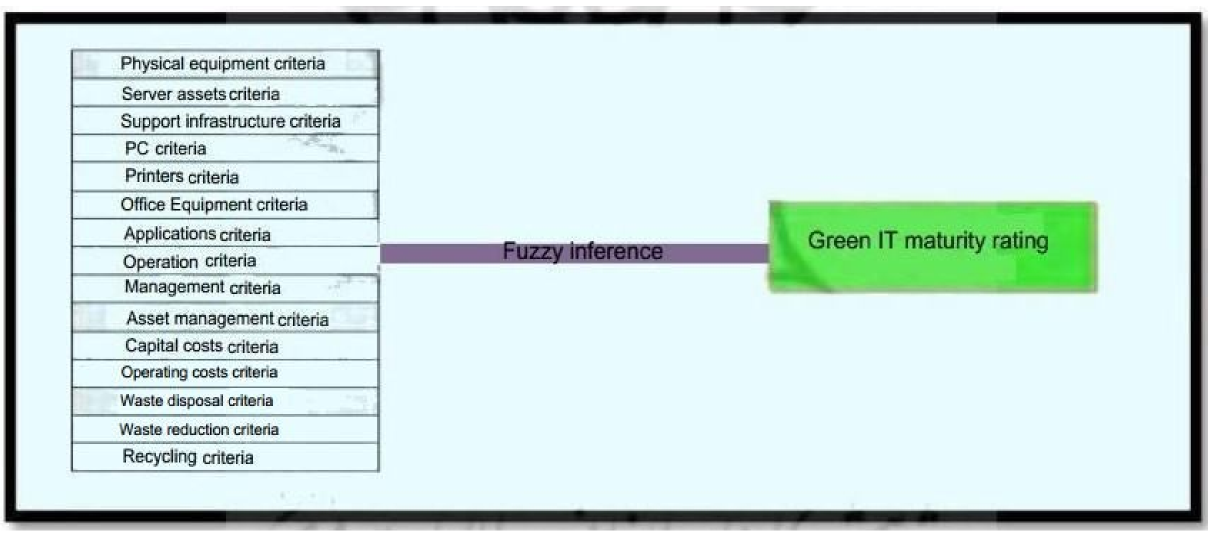


Figure 2

The Architecture of the Single-layer System



With the method of the field fuzzy inference systems, researchers designed this system. They used the Gaussian and triangular functions as the membership functions, the center of gravity method, and the maximum aggregate operator for defuzzification. The inputs of this system are factors related to the data center, office environment, process of work, procurement, and corporate citizenship, and the output of this system is the rating of GITM. In designing this system, researchers first formed the subsystems for each input. Since the input of these subsystems is related to their criteria, their output will be the score of each input. And their resulting output is considered the input of the final system, and the output of the ultimate system is the rate of the organization's GITM. The steps for designing the Fuzzy Inference System are described below.

Table 3

Evaluating the Level of Green IT Maturity

Green Maturity Levels						Criterion
Optimized (5)	**Managed (4)**	**Defined (3)**	**Repeatable (2)**	**Initial (1)**	**Incomplete (0)**	
(2.8 3.3]	(2.3 2.8]	(2.2 2.3]	(2 2.2]	(1.5 2]	[0 1.5]	Data Center
(2.4 3.3]	(2.3 2.4]	(2.2 2.3]	(2 2.2]	(1.5 2]	[0 1.5]	Office Environment
(2.6 3.7]	(1.9 2.6]	(1.7 1.9]	(1.5 1.7]	(1 1.5]	[0 1]	Work Practice
(2.2 3.3]	(1.9 2.2]	(1.7 1.9]	(1.5 1.7]	(1 1.5]	[0 1]	Procurement
(2.4 3]	(1.9 2.4]	(1.7 1.9]	(1.5 1.7]	(1 1.5]	[0 1]	Corporate Citizenship
(3.2 3.7]	(2.3 3.3]	(2.2 2.3]	(2 2.2]	(1.5 2]	[0 1.5]	The Final System

Step 1 (Design of system inputs and outputs)

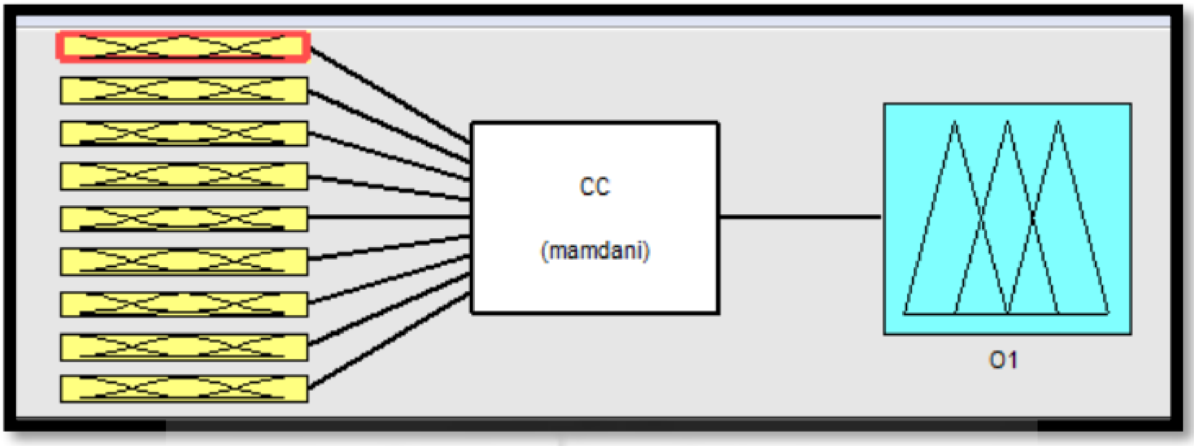
In this step, we define the input and output variables of the system. Input variables are the green IT's maturity rating in data center indexes, corporate citizenship, procurement, work practice, and office environment. The system output variable is the company's green IT maturity ultimate rating.

Step 2 (Fuzzification of input and output variables)

In this step, researchers performed fuzzy linguistic variables creation. They used symmetric Gaussian functions for input and triangular functions for output variable fuzzification. Figure 3 shows the fuzzy inference system, the input and output variables of the corporate citizenship subsystem; other subsystems are designed in the same way.

Figure 3

Corporate Citizenship Subsystem

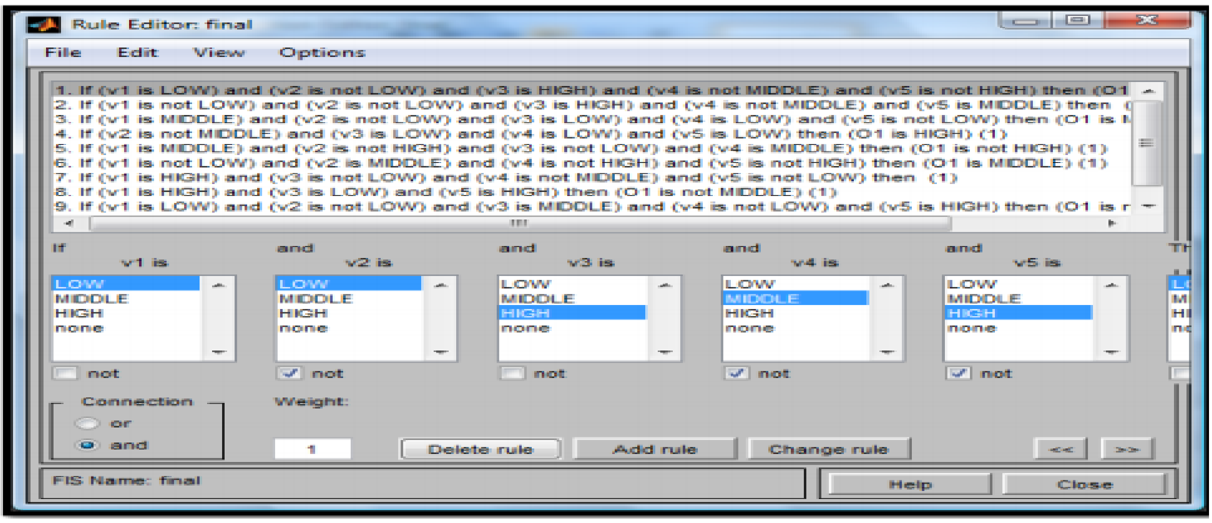


Step 3 (Fuzzy inference system rule determination)

Since a fuzzy system converts input data into output based on rules, for its completion and to define the system rules logically, further research is needed. The final system is derived from the aggregation of five subsystems. According to the opinion of 5 experts, researchers developed 12 rules for each subsystem. Figure 4 shows part of the rules of the hybrid system.

Figure 4

Hybrid System Rules



Step 4 (Defuzzification)

In this step, the central gravity method has been used.

Results

At the end of the designing phase, researchers initiate a validation phase to investigate and prove the accuracy of the hybrid inference system which includes five subsystems. For testing the system in the first part, they comprised the system test results and the mean and evaluated values for different industries in Korea. In the second section, they used the sensitivity analysis of the variables and a case study in an organization to verify the system's validity. The results of all three methods stated the system's excellent reliability and efficiency. To validate the results of the designed system, they obtained Park et al. (2012) numbers for different industries in Korea, used them as inputs, and compared the results with the system's outputs. Tables 4 and 5 show the system errors in this comparison.

Table 4

Combined Subsystems Test Scores with the Average Green Information Technology Maturity Rating of Korea

Green IT Maturity Level Evaluated by the System	System Deviation	System Value	Average Value in Korea	Criterion Name
Managed (level 4)	0.05	2.65	2.7	Data Center
Optimized (level 5)	0.09	2.61	2.7	Work Practice
Repeatable (level3)	0.14	2.16	2.3	Office Environment
Managed (level 4)	0.07	2.13	2.2	Corporate Citizenship
Optimized (level 5)	0.55	2.45	1.9	Procurement

Table 5

Combined System Test for Various Industries in Korea

Green IT Maturity Level Evaluated by the System	System Deviation	System Value	Average Value in Korea	Industry
Defined (Level3)	0.58	2.22	2.8	Petrochemicals/Chemicals
Managed (Level4)	0.03	2.27	2.3	Medical care/Pharmaceuticals
Defined (Level3)	0.44	2.24	1.8	Utilities/Construction
Defined (Level3)	0.56	2.26	1.7	Public Corporations/Institutions
Defined (Level3)	0.15	2.25	2.4	Finance/Insurance
Repeatable (level 2)	0.2	2.2	2.4	Information and Communications/Media
Defined (Level3)	0.55	2.25	2.8	Logistics/Distribution
Defined (Level3)	0.16	2.24	2.4	Manufacturing
0.15	Average total system error in industries			

Then, researchers used the obtained subsystems assessment results to evaluate the average of the organization's green IT maturity final score and corresponding level. Table 6 shows the results of the hybrid system.

Table 6

Outcomes of Green IT Maturity

Green IT Maturity Level Evaluated by the System	Amount of Deviation	Score of The System	The Mean Value of Green Maturity in Korea	System Type
Defined (Level 3)	0.17	2.23	2.4	Hybrid

Researchers used the output behavior analysis method to test the model. In this method, the size of all input variables is constant except one which increases or decreases for analysis. Since the inference system evaluates the output size based on any reduction or deduction, setting adjacent values for measures form output behaviors. After analyzing the reaction, if the research literature or the opinion of experts verifies the output, the inference system is justified; otherwise, it needs modifications. In this study, the theoretical foundations and expert opinions confirmed the result of the inference system. Finally, researchers used the inference system for validity investigation and practical application for the Tehran municipality. They asked six green IT experts to answer the standard questionnaire of Park and Associates (2010). They used averaged responses as a benchmark for the system to evaluate green IT maturity. The organization's GITM level was level 3 (defined) with a 2.24 score system rating.

Conclusion

Though there has been so much debate on climate change and its effects as a global issue, there have been some vague points on how the information technology industry can become greener. Since green IT helps organizations decrease their carbon footprints alongside increasing revenue, it has been in the spotlight for the last couple of years. The crucial missing step in going greener is to understand the current level of maturity in green IT for each organization. The proposed fuzzy inference solution in this study is beneficial for green IT maturity evaluation. So far, green information technology, which itself can be an utterly fuzzy concept, is not modeled using fuzzy logic, and this is the scientific contribution of this research. In domestic research, in recent years, attention has been paid to the issue of greenness in various organizational issues (Andalib Ardekani & Keshavarz, 2016; Bahramizadeh & Rezaei, 2016; Khadivar & Dortaj, 2021). However, modeling the green knowledge has not been found in any of this research. The model used in this paper is a standard model used to evaluate and compare GITM in various industries around the world. Therefore, the resulting fuzzy inference system also has this strength and can be generalized. Understanding the status is a vital pre-step for strategic planning to become a more IT-green organization. Accordingly, authors recommend organizations with environmental concerns use this inference system to evaluate their current GITM level. The proposed hybrid inference system consists of five subsystems with comprehensive research on indicators giving organizations a better understanding of criteria needing their observations. The authors also recommend that interested researchers investigate other beneficial models for inference system development in this context for further research. The reliance on a particular model, as it can be the strength of the research, is also a research constraint.

Subscripts

1. Information technology

2. Green IT maturity model integration

3. MATLAB

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Akman, I., & Mishra, A. (2015). Sector diversity in Green Information Technology practices: Technology Acceptance Model perspective. *Computers in Human Behavior*, *49*, 477-486. https://doi.org/https://doi.org/10.1016/j.chb.2015.03.009

Andalib Ardekani, D., & Keshavarz, P. (2016). Assessment the green product development and its impact on customer's mental image with structural equation modeling approach (case study: food industry in Yazd province). *Journal of Modern Research in Decision Making*, *1*(3), 85-112. https://www.magiran.com/paper/1602217

Anthony, B., Majid, M. A., & Romli, A. (2020). A generic study on Green IT/IS practice development in collaborative enterprise: Insights from a developing country. *Journal of Engineering and Technology Management*, *55*, 101555. https://doi.org/https://doi.org/10.1016/j.jengtecman.2020.101555

Asadi, S., Nilashi, M., Samad, S., Rupani, P. F., Kamyab, H., & Abdullah, R. (2021). A proposed adoption model for green IT in manufacturing industries. *Journal of Cleaner Production*, *297*, 126629. https://doi.org/https://doi.org/10.1016/j.jclepro.2021.126629

Ateetanan, P., & Usanavasin, S. (2015). Assessing Green IT Maturity and Recommendation of Improvement for Government Agencies in Thailand. *Journal of Business Administration and Languages (JBAL)*, *3*(2), 7-12.

Bahramizadeh, M., & Rezaei, B. (2016). Meta-Analyzing and Identifying Factors Influencing Green Purchasing Decisions Behavior. Management Research in Iran (Modares Human Sciences), 20(2), 21-48. SID. https://sid.ir/paper/356812/en

Bhadauria, V. S., Toms, L., Green, K. W., & Meacham, J. (2014). Do green information systems impact performance? *International Journal of Productivity and Quality Management*, *13*(4), 377-394. https://doi.org/10.1504/IJPQM.2014.062218

Chilamkurti, N., Zeadally, S., & Mentiplay, F. (2009). Green Networking for Major Components of Information Communication Technology Systems. *EURASIP Journal on Wireless Communications and Networking*, *2009*(1), 656785. https://doi.org/10.1155/2009/656785

Dalvand, A., Abbasianjahromi, H., Ravanshadnia, M., & Zeighami, E. (2022). Designing a Mamdani Fuzzy Inference Expert System for evaluating Human Resources in the Iranian Construction Industry. *Interdisciplinary Journal of Management Studies (Formerly known as Iranian Journal of Management Studies)*, *15*(4), 851-873. https://doi.org/10.22059/ijms.2021.328145.674680

Desai, M., & Bhatia, V. (2011). Green IT Maturity Model: How does your Organization Stack up? *SETLabs Briefings*, *9 (1)*, 49-56.

Donnellan, B., Sheridan, C., & Curry, E. (2011). A Capability Maturity Framework for Sustainable Information and Communication Technology. *IEEE IT Professional*, *13*, 33-40. https://doi.org/10.1109/MITP.2011.2

Hankel, A., Oud, L., Saan, M., & Lago, P. (2014). A Maturity Model for Green ICT: The Case of the SURF Green ICT Maturity Model. International Conference on Informatics for Environmental Protection,

Ijab, M. T., Molla, A., Kassahun, A. E., & Teoh, S. (2010). Seeking the "Green" in "Green IS": A Spirit, Practice and Impact Perspective. Pacific Asia Conference on Information Systems,

Imasiku, K., Thomas, V., & Ntagwirumugara, E. (2019). Unraveling Green Information Technology Systems as a Global Greenhouse Gas Emission Game-Changer. *Administrative Sciences*, *9*(2).

Jayaprakash, P., & Pillai, R. (2020). Assessing the business dimensions of green IT transformation: a case of an Indian IT organization. *International Journal of Information Technology and Management*, *19*, 68. https://doi.org/10.1504/IJITM.2020.104505

Jenkin, T., Webster, J., & McShane, L. (2011). An agenda for 'Green' information technology and systems research. *Information and Organization*, *21*, 17-40. https://doi.org/10.1016/j.infoandorg.2010.09.003

Khadivar, a., & Abdian, s. (2018). Modeling the maturity of green information technology with the system dynamics approach. *mdrsjrns*, *8*(2), 73-91. http://ormr.modares.ac.ir/article-28-15887-fa.html

Khadivar, A., & Dortaj, f. (2021). Presentation a framework for success in the implementation of knowledge management systems based on cloud computing. *Management Research in Iran*, *20*(2), 93-118. https://mri.modares.ac.ir/article_395.html

Kusi-Sarpong, S., Sarkis, J., & Wang, X. (2016). Green Supply Chain Practices and Performance in Ghana's Mining Industry: A Comparative Analysis based on DEMATEL and AHP. *International Journal of Business Performance and Supply Chain Modelling*, *8*, 320-347. https://doi.org/10.1504/IJBPSCM.2016.081290

Lunardi, G. L., Alves, A. P., & Salles, A. C. (2013). Green IT Maturity: developing a framework based on practices and actions. *ONF-IRM 2013 Proceedings*.

Matthews, C. (2003). A formal specification for a fuzzy expert system. *Information and Software Technology*, *45*(7), 419-429. https://doi.org/https://doi.org/10.1016/S0950-5849(03)00013-2

Mobinikeshe, M., Khadivar, A., & Rohani, S. (2017). Evaluating green IT maturity using fuzzy inference system. *Iranian Journal of Management Studies*, *21*.

Molla, A. (2008). GITAM: A Model for the adoption of Green IT. *ACIS 2008 Proceedings - 19th Australasian Conference on Information Systems*.

Molla, A. (2009). Organizational Motivations for Green IT: Exploring Green IT Matrix and Motivation Models. Pacific Asia Conference on Information Systems,

Molla, A., Cooper, V., & Pittayachawan, S. (2009). *IT and eco-sustainability: Developing and validating a green IT readiness model*. https://doi.org/10.13140/2.1.5004.1124

Muladi, N., & Surendro, K. (2014). The readiness self-assessment model for green IT implementation in organizations. *2014 International Conference of Advanced Informatics: Concept, Theory and Application (ICAICTA)*, 146-151.

Nazari, G., & Karim, H. (2012). Green IT adoption: The impact of IT on Environment: A case study on Green IT adoption and underlying factors influencing it. *2012 Proceedings of 17th Conference on Electrical Power Distribution*, 1-7.

Ojo, A. O., & Fauzi, M. A. (2020). Environmental awareness and leadership commitment as determinants of IT professionals engagement in Green IT practices for environmental performance. *Sustainable Production and Consumption*, *24*, 298-307. https://doi.org/https://doi.org/10.1016/j.spc.2020.07.017

Park, S. H., Eo, J., & Lee, J. (2012). Assessing and Managing an Organization's Green IT Maturity. *MIS Quarterly Executive*, *11*, 127-140.

Ramayah, T., Lee, J., & Mohamad, O. (2010). Green product purchase intention: Some insights from a developing country. *Resources, Conservation and Recycling*, *54*, 1419-1427. https://doi.org/10.1016/j.resconrec.2010.06.007

Ryoo, S. Y., & Koo, C. (2013). Green practices-IS alignment and environmental performance: The mediating effects of coordination. *Information Systems Frontiers*, *15*. https://doi.org/10.1007/s10796-013-9422-0

Singh, M., & Sahu, G. (2020). Towards adoption of Green IS: A literature review using classification methodology. *International Journal of Information Management*, *54*, 102147. https://doi.org/10.1016/j.ijinfomgt.2020.102147

Srivastava, S., & Srivastava, R. (2012). Adoption of Green Information Technology (GIT) in India - A Current Scenario. *Journal of Information and Operations Management*, 3, 61-63.

Velte, T., Velte, A., & Elsenpeter, R. C. (2008). *Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line: Reduce Your Information System's Environmental impact While Adding to the Bottom Line*. McGraw Hill LLC. https://books.google.com/books?id=xPQZqKrJN7oC

Bibliographic information of this paper for citing:

Khadivar, Ameneh; Mobini Kashe, Maryam & Basraei, Raha (2024). A Fuzzy Inference System to Evaluate Maturity of Green Information Technology. *Journal of Information Technology Management,* 16 (2), 1-15. https://doi.org/ 10.22059/JITM.2023.306213.2567