

# Knowledge management model to enhance Enterprise Resource Planning system in Green software development process

Sarah M Yahya<sup>1</sup> and Mustafa S Khalefa<sup>1</sup>

<sup>1</sup>Computer science department education college of education for pure science, University of Basrah

E-mail: bathrat.amal88@gmail.com

**Abstract.** The global economy is constantly evolving and corporate technology and business are an important factor in this development and because of the accompanying negative impact on the environment and society, the role of sustainability and sustainable development highlights. To further investigate the scope of the green software development process and its integration with information systems such as the Enterprise Resource Planning (ERP) system, we presented this study due to its importance in minimizing the negative effects of information technology on our natural environment. In this connection, there is a have to combine sustainability and information technology allow organizations to behave in a manner to going greener. Comprehending that the Enterprise Resource Planning (ERP) system is one of the very effective commercial enterprise solutions for organizations, it is necessary to align its use with sustainability factors through the utilization of green IT practices, the objective of this research study is to provide a design model to enhance ERP system in green software development process. So every company must look into the impact of the utilization of Information and communications technology (ICT) on our natural environment and take care to adopt methods to decrease the effects negative on its. Therefore, knowledge management (KM) can be used as the facilitation tool. This research paper presents the results of qualitative research, which proposes a model that to the possibility of enhancing the implementation of the ERP system in the Green Software Development Process by using green IT practices and knowledge management as facilitation tools.

## 1. Introduction

The global economy is constantly evolving and corporate technology and business are an important factor in this development and because of the accompanying negative impact on the environment and society, the role of sustainability and sustainable development highlights. This actually is the place the sustainability idea is needed, with the purpose to make a balanced interplay between economic investments, useful resource utilization, and social advancement for modern wishes and future potentials[1], [2]. In this connection, there is a have to combine sustainability and information technology allow organizations to behave in a manner to going greener [3]. The green or Greenness has become an important topic that goes into all aspects of life around the world including information technology and business. In general, Merriam-Webster (An American Dictionary of the English Language) defined a green is "tending to preserve environmental quality (as by being recyclable, biodegradable, or non-polluting)" [4].

In 2018, Hayri ACAR consider sustainable software at the outside of the green software. Therefore, that mean the green must respect sustainable criteria. In this regard, UN cited the sustainability criteria only have three main dimensions, which are economic growth, environmental protection, and social equality[5].



Because the globalization changing very speedily in business, competition increased, and information technology rapidly growths, companies have to undertake enterprise resource planning (ERP) systems furnished with software program and hardware amenities[6][7] to typically meet the technical data necessities of companies along with the desire of owner to strengthen corporate competitiveness[8].

Comprehending that the Enterprise Resource Planning (ERP) system is one of the very effective commercial enterprise solutions for organizations, In doing so, it have now been an important contributor to environmental degradation brought on by resource consumption, greenhouse (carbon) emissions, and wastage[9]. As a consequence, it's essential to align its use with sustainability elements through the utilization of green information technology (IT) [3], So every company must look into the impact of the utilization of Information and communications technology (ICT) on our natural environment and take care to adopt methods to decrease the effects negative on its [3][9][10].

## 2. Related work

The development of information and communication technologies has an impact on the development of all types of software and applications in the organization. At the same time, the phenomenon of globalization and the external environment were more complex with the new need and conditions for institutions in terms of reducing the negative effects on the environment[11]. For this reason, a high-quality information system is now a necessity for every enterprise to be capable to make bigger competitiveness with the aid of decreasing fees via higher logistics. Previous reviews of the literature need more research in the scope of the green software development process, as well as little research on the topic of green software development process with ERP system, so we focused on this as shown in (Figure 1) where we note that the ERP system and the software development process and knowledge management are all within the environment of the green software development process, and this leads to a high quality of data and software in the enterprise. In these circumstances, companies have two challenges: to generate and put in force an infrastructure for information technologies with purposes for storing and sharing information and to successfully use this information for the decision-making process[11].

Because of the negative effects on the environment resulting from its software, systems, and applications in organizations[3], the objective of this study is to the possibility of enhancing the implementation of the ERP system in Green SDP by using green IT practices and knowledge management as a facilitation tools. Moreover, knowledge can also being a significant intangible asset to attain success in the situation of green sustainable development [12]. The organization can take advantage of the benefits of ERP systems and knowledge management and achieve success in the competition globally[11]. In this regard, In 2003 Darshana Sedera et al. propose a model to empirically assessing the impact of KM on the success of ERP systems.

In 2007 Rosemary and Sukunesan show there is an opportunity that may be explored, are the many companies that undertake IT implementation towards sustainable development and many of those companies have a basis in KM[13]. Currently, organizations have assigned very significance to the knowledge, which is generated internal and external the company, think about it an priceless asset to acquire sustainable benefits and due to the have an effect on enhancing their processes, rendering it fundamental to generate techniques focused at knowledge management[14].

In this regard, Pattarin and Vichita in 2019 developed a framework by means of integrating the essential concepts from sustainability and knowledge management [1]. In 2019, Minodora, et al. proposed a framework to explore the connection between green IT practices and ERP to check how green IT provides a chance for organizations to enhance ERP in greater environmentally answerable initiatives [3]. However, they published that the connection between ERP and green IT practices is now not relevant, specifically due to the fact of the low stage of environmentally friendly lifestyle inside companies. So they advised that organizations should start to provoke an massive layout now not simply addressing the

operational stage of these systems, however moreover the integration of sustainability factors in software program quality, administration elements of ERP implementation, or enterprise attitudes to going green[3].

In this regard, the objective of this study is to possibility of enhance the implementation of ERP system in Green SDP by using green IT practices and knowledge management as a facilitation tools. This leads to new knowledge in this field that combines ERP, Green SDP, SDP and KM, as well as focusing on the quality factor of data and software.

### 3. Methodology

The objective of this research study is to provide a design model to enhance ERP system in green software development process by using green IT practices and knowledge management as a facilitation tools , to achieve this objective, we conducted are:

1. Reconnoitering of previous studies on the subject of the research study based on keywords such as Green Process Software Development (GSDP), Software Development (SDP) or it is also called Software Development Lifecycle (SDLC), Project Planning (ERP) and Knowledge Management (KM).
2. Analysis (filtering and summarizing) the existing researches, provide a systematic review.
3. Propose and design a model to enhance the ERP system in the green software development process.

### 4. Propose model

Based on the literature review and to achieve the goal of this paper, we propose a design model to enhance ERP system in GSDP. This model consists of five components: ERP, software development process, green software development process, green IT practices, and knowledge management. The importance of this model comes from the green software development process, which is about producing nature-friendly software products with the aim of reducing the terrible environmental impacts on our environment, using green IT practices in SDLC that can be successfully implemented. (Figure 1) shows the model proposed.

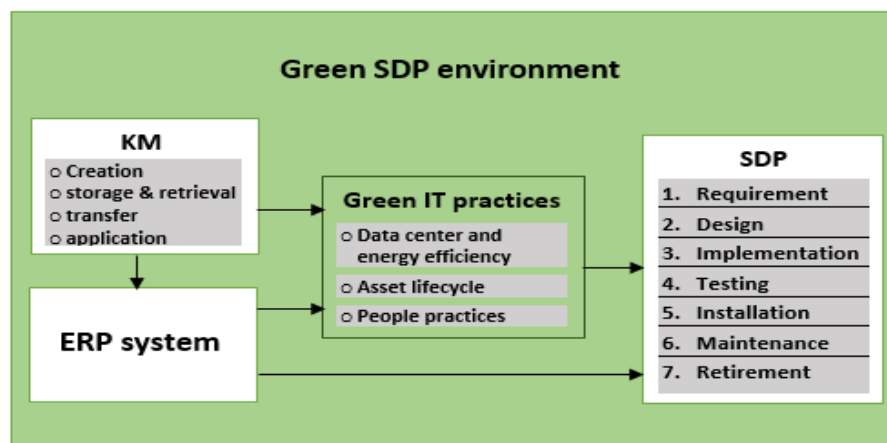


Figure1. ERPs in Green SDP model

#### 4.1. ERP system

ERP system is one of the integrated information systems, which continues to evolve as information technologies evolve and business requirements continue to diversify [8], [15]. The opinions about ERP evolution are different; Rashid et al. (2002) described that evolution as follows: in the 1960s the

organizations were used inventory control packages to automating systems, were using programming languages to writing like COBOL and FORTRAN. In the 1970s, Material requirement and planning (MRP) structures had been used to sketch the requirements of product and components inside a process of production[16]. After that, at 1980s, manufacturing resource planning (MRPII) was evolved to enhance the process of production; it added modules to include business planning, production planning, finance, engineering, human resources, distribution, and shop floor in one computer system (Wallace, 1990). Then these concepts expanded, were appeared ERP systems in the 1990s, which have the ability to integrate the business processes throughout a company[8][17].

Irwan et al. 2018, defined ERP "is a software for business management system which integrates all business functions, processes, and information between different departments inside the company. This business software system will allow companies to automate and integrate the majority of their business processes, share common data and practices across the entire enterprise, and produce and access information in a real-time environment"[18].

ERP systems may provide a company with multiple benefits. However, it is very important these benefits outweigh the expenses of the system and they need to provided that the proper system for the company is chosen and the system is implemented properly[7]. According to Deloitte 1998, the ERP system is a software system package for business[19] that lets in the enterprise to: automate and combine the majority of its enterprise processes, share common practices and data throughout the whole enterprise produce, and get admission to information in real-time.

There are many vendors, which provide an ERP system like SAP, Oracle, Microsoft et al.; they have relied on various ERP software programs according to customer needs. Most ERP solutions run along with Unix and Linux operating systems or Windows platform[20] [21]. We will take SAP ERP system as a case study. SAP word abbreviation means "Systems Applications and Products" in Data Processing. (SAP AG) by using definition, can be the title of the ERP software program alongside the title of the organization. SAP AG Software is absolutely a European multinational, established in 1972 by five engineers were worked at the IBM company are Plattner, Wellenreuther, Hector, Tschira, and Hopp. They improve software program solutions for client relationships and managing enterprise operations[22]. In practice, this business enterprise software program is known as (SAP), and the professional name is SAP ERP. (SAP AG) is the world's greatest provider of business enterprise software program that, in 2017, served extra than 345,000 clients in over a hundred ninety nations (SAP AG, 2017b). The Enterprise Software section of the organization has developed industry-specific features in the software product for over twenty-five industries to client relations and manage commercial enterprise operations for organizations [23].

SAP provides ERP solutions, to all enterprise areas, inclusive of midsize and small businesses. Where SAP launched its first ERP software program in 1979 as R/2, then redesigned the software program in 1992 the usage of a client-server architecture. R/3 used to be the ensuing software; it grew to be an immediately hit. With the assertion of it a client-server SAP R/3 system, SAP AG, which already the greatest issuer in the ERP market, brought a system that used to be attractive to small-sized and medium organizations in addition to the large organizations that already make use of SAP software program [24]. The key features of SAP R/3 software are:

1. SAP R/3 software runs on truly any software/hardware platform and may use numerous database management systems.
2. The programing code of SAP R/3 is wrote in an interpretive language known as ABAP. (ABAP is a German abbreviation that, translate as loosely, mean "Advanced Business Application Programming"). ABAP is very comparable in its syntax to COBOL. Use of the ABAP language permits SAP clients to increasing the functions of the software product.

SAP presents a massive array of widespread reports and a report writer, "Advanced Business Application Programming" (ABAP). ABAP programming language is an object-oriented environment that generates reports or transactions. The ABAP surroundings limited in offers some automatic report generation and query tools. To obtain the total advantage of the ABAP surroundings, one should be a proficient programmer [20].

Generally SAP ERP is primarily based on a database that treats with numerous commercial enterprise features interior exclusive modules like finance, sales, purchase, human resources, inventory, and manufacturing [23]. However, SAP ERP is a commercial enterprise system designed to assist the optimization of business processes within an enterprise and associated process management activities[25][26].

#### 4.2. Software development process

SDP is also called SDLC "Software development life cycle" is a procedure that produces a software program with the very best high-quality and lowest price in a short time. SDLC consists of a detailed sketch for how to develop, maintain, replace, and alter a software system[27]. However, SDP is a systematic technique for developing software program applications. Introducing any idea early in the SDLC can make sure that the idea is propagated via a number of phases [28].

Below are the software development lifecycle stages:

1. Requirement: gather all the information and requirements to conceive a concrete expectation to the software product.
2. Design: is a phase do a clear and expert design of the system and software to obtain all the requirements of the preceding phase with the aid of the developers and architects of the system.
3. Implementation: The software design will now be translated into code.
4. Testing: each module will be tested to make sure that the software product is completely free of any defects.
5. Installation: install the product up to be ready for customer use.
6. Maintenance: fine-tuning and enhancements of the system and begin planning to the feasible features and functionalities that should be inserted into the software.
7. Retirement: is the removal of a software release from production, it is also known as system decommissioning.

#### 4.3. Green software development process

Green or Greenness has become an important topic that goes into all aspects of life around the world including information technology and business. In general, Merriam-Webster (An American Dictionary of the English Language) defined a green is tending to reserve environmental qualities (such as by being biodegradable, recyclable , or non- contaminating)[4]. In 2018, Hayri ACAR consider sustainable software at the outside of the green software. Therefore, that mean the green must respect sustainable criteria. In this regard, UN cited the sustainability criteria only have three main dimensions, which are economic growth, environmental protection, and social equality[5].

GSD is a methodical processes which allow a disciplined, systematic and well-organized development of green software products[12]. Green SD is concerning to use green finest practices during SDLC process. The Key idea of Green SD is regarding manufacturing of nature-friendly software products with the aim of minimizing negative ecological impacts to our natural environment[29][30]. The main goal of GSD is about using green practices in SDLC for making greener software products, including any kinds of application software and system software products[31][32][28].



GSD includes seven phases: 1) Requirement, 2) Design, 3) Implementation, 4) Testing, 5) Installation, 6) Maintenance, and 7) Retirement [33]. Consciousness of environmental concerns and green practices must certainly be promoted at the starting of the software development [31][34]. Alike, building a secure software, security concepts should be presented in the initial SDLC phases. Likewise, presenting energy awareness early confirms that the energy-related expenditures could be minimized in later SDLC phases[28]. McXin Tee, Rusli Abdullah, J. Din, S. Abdullah, and L. Wu (2017) proposed a framework to explore relations between five independent variables (ethical motivation, competitive motivation, managerial motivation, financial motivation, and regulatory motivation) and Green SD adoption through using KM acts as simplification tools[29]; But the result of the empirical analysis showed the only motivating factor that expressively contributes to motivate software practitioners in adopting Green SD is the ethical motivation.

#### 4.4. Green IT practices

Green practices are expressed as collections of knowledge about green policies and activities that gather the most common environmental issues[35][31]. To do make work environment harmful and decreasing the overall expense of ownership, green IT proposes some of the main pros that can be done if green policies and frameworks based on green IT should be implemented correctly. Some of these benefits are[36]:

1. Green IT reduces total energy costs of the organizations.
2. It extends or elongate the life of existing data center kit by cleverly revitalizing equipment, taking benefit of energy efficiencies.
3. It lowers IT maintenance actions and costs and improves over- all impression of the organization.
4. It reduces environmental stewardship and saves money and by appropriate disposal of discarded and toxic hardware, by suggesting new hardware's which are environment friendly, consume less energy and easy to get rid of.
5. It reduce global warming effects by reducing overall carbon footprints.
6. It reduces smog, Acid rains and global climate change effects.
7. It reduces the emanation of CO<sub>2</sub>, thereby reducing the respirational problems faced by different types.
8. It reduces the straining on the electricity grid.
9. Free up spaces on data center floors.

Thus, based on the green IT maturity model suggested by Foogooa et al. [37], the next three focal points are contained in the model in our research: energy efficiency and data centers, asset lifecycle, and people practices[3].

#### 4.5. Knowledge management

KM is defined as a cyclical process concerning to phases of collecting knowledge from varied sources, then storing the knowledge in an appropriate format and place, and finally upgrading the present knowledge with the goal of making new values to organizations[29], [38], [39]. Knowledge is really a melted mixture of experience, related information, and expert insight that provides a construction for evaluating and combining new experiences and information. It initiates and is applied in the awareness of a knower[40][14].

Knowledge could be split into two kinds: explicit knowledge and tacit knowledge. The tacit knowledge is the better practices, intuitions, heuristic, special know-how, practical skills, and so on. Its individual

knowledge that's difficult to formalize or expressive. The explicit knowledge could be transmitted and codified in recognized and systematic language[40].

The utilization of KM can upraise sustainability through its essential processes and activities[1]. KM processes are composed of four groups of activities working with the management of explicit and tacit knowledge within the organization[41].

1. Knowledge creation: could be the improvement of new knowledge or replacement of the existing one, where inventions and solutions are generated.
2. Knowledge retrieval and storage: are described the memory that preserves, keep and share knowledge across time and space, which supports reduce replication of work and wastefulness of resources.
3. Knowledge transfer: could be the exchange of knowledge at different levels between individuals, groups, or organizations using various communication methods.
4. Knowledge application: is the process that knowledge is utilized in practice to be able to bring competitive advantage to life.

And the knowledge evolution cycle consists of five phases [42]:

1. Originate/create knowledge: members of an organization develop knowledge through learning, problem solving, innovation, creativity, and importation from outside sources.
2. Capture/acquire knowledge: members acquire and capture information about knowledge in the explicit forms.
3. Transform/organize knowledge: in written material and knowledge bases.
4. Deploy/access knowledge: organizations distribute through education, training program, and automated knowledge base system or expert networks.
5. Apply knowledge: KM aims to make knowledge available whenever it is needed.

## 5. Discussion

In this paper, We got to know the ERP system (definition, stages of development, importance and suppliers... etc.) of many research papers, as well as identifying the most important practices applied in the software development lifecycle to get a practical environment for the development of green software, which must be without or less an impact on the environment. In addition, we got know the importance of knowledge management in the organization and its relationship with the project planning system and the green software development environment.

The proposed model for improving the implementation of ERP system in the green software development process environment is important in improving software quality as well as knowledge quality because it requires the implementation of ERP in a pure, environmentally friendly environment, with less of (energy consumption, carbon emissions and waste of resources).

## 6. Conclusion

The adoption of ERP system is important for companies around the world, and the implementation of ERP continues to face many problems. There are many studies in this regard, but there is no framework that demonstrates the possibility of improving the implementation of the ERP system in a green software development process environment as it is pure and environmentally friendly.

In this paper we propose a model to improve the implementation of the ERP system in a green software development process environment based on knowledge management and IT practices as support tools. The result model shows how knowledge management has been used as a management to enhance the green software development process environment.

In the future, we will provide a questionnaire for specialists in this field to verify the validity of the model, and we suggest that there should be a field study of some companies that use ERP system in Iraq/Basra and urge them to implement the system in a friendly environment. One of the limitations of this study is that it is a theoretical study, not an application, as well as the ability to develop an algorithm for the model.

## 7. Acknowledgments

We would like to express our thanks to everyone who helped us complete this research.

## 8. References

- [1] P. Sanguankaew and V. V. Ractham, 'Bibliometric review of research on Knowledge Management and sustainability, 1994-2018', *Sustain.*, vol. 11, no. 16, 2019.
- [2] C. More and C. More, 'Environment, economy and society', *Ind. Age*, vol. 196, pp. 208–212, 2019.
- [3] M. Ursacescu, D. Popescu, C. State, and I. Smeureanu, 'Assessing the Greenness of Enterprise Resource Planning Systems through Green IT Solutions: A Romanian Perspective', *Sustainability*, vol. 11, no. 16, p. 4472, Aug. 2019.
- [4] 'Green | Definition of Green by Merriam-Webster'. [Online]. Available: <https://www.merriam-webster.com/dictionary/green>. [Accessed: 07-Jul-2020].
- [5] H. Acar, 'Software development methodology in a Green IT To cite this version: Software development methodology in a Green IT environment', 2018.
- [6] W. H. Tsai, K. C. Lee, J. Y. Liu, S. J. Lin, and Y. W. Chou, 'The influence of enterprise resource planning (ERP) systems' performance on earnings management', *Enterp. Inf. Syst.*, vol. 6, no. 4, pp. 491–517, 2011.
- [7] H. M. Beheshti and C. M. Beheshti, 'Improving productivity and firm performance with enterprise resource planning', *Enterp. Inf. Syst.*, vol. 4, no. 4, pp. 445–472, 2010.
- [8] S. Y. Huang, A. A. Chiu, P. C. Chao, and A. Arniati, 'Critical success factors in implementing enterprise resource planning systems for sustainable corporations', *Sustain.*, vol. 11, no. 23, 2019.
- [9] J. Vom Brocke, S. Seidel, and J. Recker, 'Green business process management: Towards the sustainable enterprise', *Green Bus. Process Manag. Towar. Sustain. Enterp.*, vol. 9783642274, no. June 2016, pp. 1–251, 2013.
- [10] T. Butler, 'Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS', *J. Strateg. Inf. Syst.*, vol. 20, no. 1, pp. 6–26, 2011.
- [11] I. Vrdoljak, 'ERP Concept for Enterprise Management and Knowledge Management Era', *New Trends Technol. Control. Manag. Comput. Intell. Netw. Syst.*, 2010.
- [12] R. Abdullah, S. Abdullah, J. Din, and M. Tee, 'A SYSTEMATIC L ITERATURE R EVIEW OF G REEN S OFTWARE D EVELOPMENT IN C OLLABORATIVE'.
- [13] R. Van Der Meer and S. Sinnappan, 'The Role of Knowledge Management in an Organisation ' s Sustainable Development', pp. 450–454, 2007.
- [14] L. Fernando, S. Joya, L. Eduardo, B. Ardila, L. Eduardo, and B. Ardila, 'Model for Knowledge Management in Software Project Planning in University Research Groups', vol. 9, no. 16, pp. 58–64, 2014.
- [15] A. Gholamzadeh Chofreh, F. A. Goni, S. Ismail, A. Mohamed Shaharoun, J. J. Klemeš, and M. Zeinalnezhad, 'A master plan for the implementation of sustainable enterprise resource planning systems (part I): concept and methodology', *J. Clean. Prod.*, vol. 136, no. July 2018, pp. 176–182, 2016.
- [16] A. mike, 'Analysing the Impact of Enterprise Resource Planning', *Www.Ejise.Com*, pp. 103–113, 2001.



- [17] M. Rashid, L. Hossain, and J. Patrick, *Enterprise Resource Planning*. IGI Global, 2002.
- [18] I. Ibrahim, N. A. Jamil, and I. A. Halin, 'Green Enterprise Resource Planning and Green Logistics Performance', *SIJ Trans. Ind. Financ. Bus. Manag.*, vol. 06, no. 03, pp. 01–06, Jun. 2018.
- [19] E. Processes, 'ERP ' s Maximizing the Value of Erp-Enabled Processes', *Business*, p. 28, 1998.
- [20] G. T. Timbrell, 'A meta-study of SAP financials in the Queensland Government', 2006.
- [21] F. Alizai, 'A model for the implementation of ERP systems in midsize businesses', no. November, pp. 1–391, 2014.
- [22] 'What is SAP? Definition of SAP ERP Software'. [Online]. Available: <https://www.guru99.com/what-is-sap-definition-of-sap-erp-software.html>. [Accessed: 09-Jul-2020].
- [23] M. Grube, 'The impact of SAP on the utilisation of business process management (BPM) maturity models in ERP projects', *CEUR Workshop Proc.*, vol. 2196, no. February, pp. 6–10, 2018.
- [24] J. M. Esteves de Souza, 'Definition and analysis of Critical Success Factors for ERP implementation projects', *Thesis*, pp. 1–313, 2004.
- [25] N. Dechow, M. Granlund, and J. Mouritsen, 'Management Control of the Complex Organization: Relationships between Management Accounting and Information Technology', *Handbooks Manag. Account. Res.*, vol. 2, pp. 625–640, 2006.
- [26] N. Williams, 'IT Service Management in SAP Solution Manager', 2013.
- [27] S. Ray, 'Journal of Global Research in Computer Science[[Elektronische Ressource]] JGRCS', *J. Glob. Res. Comput. Sci.*, vol. 4, no. 1, pp. 25–29, 2013.
- [28] N. S. Chauhan and A. Saxena, 'A green software development life cycle for cloud computing', *IT Prof.*, vol. 15, no. 1, pp. 28–34, 2013.
- [29] M. Tee, R. Abdullah, J. Din, S. Abdullah, and L. Wu, 'Green SD adoption using knowledge management facilitation – A motivational perspective', *J. Theor. Appl. Inf. Technol.*, vol. 95, no. 17, pp. 4291–4303, 2017.
- [30] B. Penzenstadler and H. Femmer, 'A generic model for sustainability with process- and product-specific instances', *GIBSE 2013 - Proc. 2013 Work. Green Softw. Eng. Green by Softw. Eng.*, pp. 3–7, 2013.
- [31] M. Tee, R. Abdullah, and L. Wu, 'Towards Developing Agent-Based KMS In Managing Knowledge of Green SD For Community of Practice', vol. 9, no. 2, pp. 71–76.
- [32] C. Calero and M. Piattini, 'Green in software engineering', in *Green in Software Engineering*, 2015, pp. 1–327.
- [33] M. Dick and S. Naumann, 'Enhancing Software Engineering Processes towards Sustainable Software Product Design', *EnviroInfo 2010, Integr. Environ. Inf. Eur. Proc. 24th Int. Conf. Informatics Environ. Prot.*, vol. 2010, pp. 706–715, 2010.
- [34] C. Barth and S. Koch, 'Critical success factors in ERP upgrade projects', 2019.
- [35] C. Calero and M. Piattini, 'Green in software engineering', in *Green in Software Engineering*, no. January 2015, 2015, pp. 1–327.
- [36] M. Uddin and A. A. Rahman, 'Energy efficiency and low carbon enabler green IT framework for data centers considering green metrics', *Renew. Sustain. Energy Rev.*, vol. 16, no. 6, pp. 4078–4094, 2012.
- [37] R. Foogooa, C. Bokhoree, and K. Dookhitram, 'Green ICT Maturity Models', *Ieee*, 2015.
- [38] R. Lu and J. Liu, 'The research of the knowledge management technology in the education', *Proc. - 2008 Int. Symp. Knowl. Acquis. Model. KAM 2008*, pp. 551–554, 2008.
- [39] R. Abdullah, H. Ibrahim, R. Atan, S. Napis, M. H. Selamat, and N. Haslina, 'The Development of Bioinformatics Knowledge Management System with Collaborative Environment The Development of Bioinformatics Knowledge Management System with Collaborative Environment', no. January, 2008.

- [40] M. Personal and R. Archive, 'Munich Personal RePEc Archive The Roles of Knowledge Management for the Development of Organizations', no. 83038, 2017.
- [41] M. Alavi and D. E. Leidner, 'Review: Knowledge Systems: Management Knowledge and Foundations Conceptual', *MIS Q.*, vol. 25, no. 1, pp. 107–136, 2001.
- [42] I. Rus and M. Lindvall, 'Knowledge management in software engineering', *IEEE Softw.*, vol. 19, no. 3, pp. 26–38, 2002.

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.