Sustainable management of information technologies and systems in IT organizations

Jose Manuel Lamis Rivero, Alexey Zherdev, and Juan Antonio Plasencia Soler

***Abstract*— Information and Communication Technologies (ICT) have contributed significantly to the economic and social development of contemporary society. Recent years have seen increased attention from the international scientific community towards the relationship between ICTs and sustainability, particularly in terms of cost reduction and environmental impact. Organizations are actively developing practices related to sustainable technologies and information systems. This research proposes a comprehensive approach to sustainable management of information technologies and systems through the integration of Multicriteria Methods and Compensatory Fuzzy Logic in IT projects. The application of this procedure resulted in the formulation of an action plan to enhance the impact of information technologies and systems on organizational sustainability.**

***Keywords*— Organizational sustainability, Information technology and systems management, Compensatory fuzzy logic, Green Information Systems Technology (Green IT/IS).**

I. Introduction

Information and Communication Technologies (ICT) have been a transforming force on a global scale, especially in scientific and technical development. ICTs have become essential elements in various sectors of society, particularly in business management. Global production of technology goods and services currently accounts for about 6.5% of the world's gross domestic product (GDP), and the ICT services sector alone employs about 100 million people [1].

Researchers and academics are studying ICTs' impact on social, economic, political, cultural, and ecological spheres. ICTs play an important role in development and enable educational opportunities through massive education, online information, and support in individual training [2]. Moreover, ICTs facilitate access to a vast amount of information and knowledge, promoting lifelong learning and continuous professional development.

In recent years, ICTs have become key tools for organizations, assisting in the management of processes with a strategic approach to effective decision-making, impacting personal, business, and communication spheres [3]. They enable real-time communication and collaboration, streamline operations, and enhance data management and analysis capabilities. However, constant technological changes and the speed at which they are occurring require a proactive transformation of business processes to achieve social, economic, and environmental benefits [4]. Organizations must adapt to these changes to remain competitive and sustainable in an ever-evolving digital landscape.

The international scientific community is actively exploring the positive and negative effects of ICTs. While they contribute to environmental impacts, such as greenhouse gas emissions, pollution, and waste disposal, they also add substantial value to organizational processes by enhancing sales, customer service, productivity, cost reduction, and overall efficiency [5]. ICTs enable businesses to reach global markets, improve customer engagement through personalized services, and optimize supply chain management.

Increased emissions are related to the demand for ICT goods and services, prompting the industry to innovate technologically for sustainability, primarily from economic and environmental perspectives, through continuous improvement of business processes. Despite these dual aspects, sustainability integration in ICT organizations remains an underexplored area requiring further research [5], [6]. There is a growing need to develop comprehensive strategies that address the environmental footprint of ICTs while leveraging their potential to drive sustainable development.

For these reasons, the impact of ICTs on sustainable development, specifically on organizational sustainability, has been addressed for several years through Green Information Systems (Green IS) [7] and Green Information Technology (Green IT) [8]. Initiatives such as virtualization, cloud computing, energy efficiency, and reducing the use of hazardous substances in electronic goods are being adopted by organizations to achieve sustainability in their processes. Green IT focuses on reducing the negative environmental impacts of ICT infrastructure and practices, while Green IS emphasizing the role of information systems in promoting sustainability across organizational operations.

Negative effects are mainly associated with IT emissions and waste. Therefore, ensuring that the design, production, use, and recycling of technology products or services [9] is done efficiently and effectively, without harming the environment, is known as Green IT [10]. This includes

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L. R. Jose Manuel is with National University of Science and Technology "MISIS, 2-Y Donskoy Proyezd, 7 корпус 9, Moscow, 115419, Russia; (e-mail: jmlamis1993@ gmail.com).

Z. Alexey, was is National University of Science and Technology "MISIS. Podolsk, 108823, Podolskaya st. 14, app.131, Moscow, Russia (e-mail: a.zherdev@misis.ru).

P.S Juan Antonio, was is University of Computer Sciences (UCI). San Antonio de los Baños, Km 2 ½, Boyeros, Havana, 19370, Cuba (e-mail: juanps@uci.cu).

adopting energy-efficient hardware, promoting e-waste recycling programs, and implementing sustainable data center practices. Additionally, policies and regulations that encourage environmentally responsible behavior in the ICT sector are crucial.

On the other hand, positive effects involve the development and use of information systems to improve ecological sustainability through the automation, computerization, and transformation of an organization's products and business processes, known as Green IS [11]. These systems can optimize resource use, enhance supply chain transparency, and facilitate the monitoring and reporting of sustainability metrics. By integrating sustainability into their core operations, organizations can achieve significant environmental benefits while also improving their economic performance.

The objective of this research is to develop a general procedure for the sustainable management of information technologies and systems in project-oriented organizations. The research is organized as follows: the first section deals with the impact of sustainable information technologies and systems. The second section describes the general procedure for sustainable management of information technologies and systems in IT projects. The third section presents the main results of the procedure's application in IT projects. Finally, the study's conclusions are presented.

II. Background

A. Green information Technologies and systems

Recent studies [12] and [13] reveal significant organizational efforts to maximize the positive impacts of technologies while minimizing their negative environmental effects.

Green IT emphasizes the efficient use and manufacture of technologies with minimal environmental impact. According to [13], Green IT involves the efficient and effective use of technologies designed to minimize their environmental footprint. This encompasses the production, application, operation, and disposal of IT products throughout their entire lifecycle, ensuring minimal or no negative ecological impact [14].

Moreover, Green IT strategies often involve the use of virtualization technologies and cloud computing to enhance resource efficiency. By consolidating multiple virtual servers onto a single physical server, organizations can significantly reduce their hardware requirements and energy usage. Cloud computing, with its scalable and on-demand resource allocation, further supports sustainability by allowing businesses to use only the computing power they need, thus reducing waste.

On the other hand, sustainable information systems (Green IS) refer to a set of software tools or services used to achieve organizational objectives sustainably. The scope of Green IS is broader than that of Green IT. While Green IT focuses on providing technological tools (hardware, software, and peripheral equipment) to support functions efficiently without harming the environment, Green IS emphasizes communication, shared services, enterprise resource planning (ERP), and customer relationship management (CRM) within an organizational boundary [15].

The distinction between Green IT and Green IS is essential for understanding how organizations can strategically implement sustainability practices[16] . Green IT focuses on the technical aspects and lifecycle management of IT products to reduce their environmental footprint. This includes efforts to design energy-efficient devices, reduce electronic waste through recycling programs, and utilize sustainable materials in manufacturing processes.

The ongoing development and adoption of Green IT and Green IS demonstrate the commitment of organizations to sustainable development [17]. These efforts not only contribute to reducing the ecological impact of technology but also enhance organizational resilience and competitiveness in a rapidly evolving digital landscape

The author conducted a survey of several scientific researches [17-20] in search of Green IT/IS initiatives and practices. Table I. shows a summary of the main practices exposed in the literature for the sustainability of information technologies and systems.

Table I. Practices for the sustainability of information technologies and systems.

Green IT Practices	**Green IS Practices**
Centralize the supply of technological equipment. Purchase of paper and ecological cartridges. Virtualization of servers. Monitoring the energy consumption of servers. Virtualization of networks. Cloud computing. Extending the life cycle of technological equipment. Use of laptops. Installation of thin clients. Recycling of equipment and its components. Activation of energy management functions in computers. Installation of power management applications. Sharing multifunction printers on the network. Default configuration of double-sided sheet printing on printers.	Remote work practices and virtual meetings. Implementation of environmental management systems. Certification in Environmental Management Systems. Use of advanced logistics systems. Dematerialization. Establishment of environmental objectives. Monitoring of IT-related environmental indicators. Implementation of an energy management system. Internal and external communication of energy saving initiatives. Intelligent sensors for the control and optimization of energy flows. Monitoring and analysis of waste and emissions. Smart manufacturing. Use of advanced automation technologies. Building automation.

In general, IT is often seen as "part of the problem" due to its environmental impact during its life cycle, such as energy consumption in data centers and electronic waste (e-waste).

Green IT focuses on mitigating these effects by promoting energy efficiency, reducing e-waste, and implementing sustainable practices throughout the IT lifecycle. Examples include the use of energy-efficient servers, virtualization technologies to reduce hardware needs, and e-waste recycling programs.

However, information systems (IS) are viewed as "part of the solution," leveraging their potential to support sustainability initiatives, such as environmental management systems that help organizations monitor and reduce their environmental impact

B. Green IT/IS frameworks

The author conducted a comprehensive literature review to explore the adoption of sustainable technologies and systems within organizations [21-24]. This review synthesizes insights from a wide range of studies, offering a detailed summary of the key frameworks, models, and methodologies that have been proposed in the literature. Through this synthesis, the review highlights the diverse approaches and strategies that organizations are employing to integrate sustainability into their technological and operational processes.

The review reveals that many publications on models, frameworks, and methodologies for sustainable information technologies and systems propose theoretical concepts that have not yet been practically implemented. While these theoretical models offer valuable perspectives, they require empirical validation to determine their effectiveness in real-world scenarios.

Additionally, a significant portion of the research predominantly focuses on the environmental aspects of Green IT and Green IS. While these studies provide valuable insights into reducing ecological footprints, they often overlook the broader potential of these technologies to enhance overall business processes. In particular, there is a tendency to neglect the consideration of economic, social, cultural, legal, technological, and institutional factors that are crucial for a holistic approach to sustainability.

Much of the existing research tends to be concentrated on specific components, such as green management practices in data centers, the optimization of the IT value chain, and the integration of corporate social responsibility strategies. While these areas are critical, the studies do not always succeed in developing a fully integrated approach to managing Green IT/IS within organizations.

In the studies reviewed by the researchers, a set of dimensions related to the sustainable management of information technologies and systems were defined, primarily from a life cycle perspective. These dimensions include Sustainable Use, Sustainable Acquisition, Sustainable Manufacturing and Development, Sustainable Design, Sustainable Governance, and Reuse, Recycling, and Waste Management.

The literature review also highlights various models, frameworks, and methodologies for sustainable information technologies and systems, emphasizing the importance of multi-criteria decision-making methods such as the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP). These methods are crucial for evaluating and prioritizing sustainability initiatives, allowing organizations to systematically assess multiple criteria and make informed decisions that balance environmental, economic, and social considerations.

III. General procedure for the sustainable management of information technologies and systems in IT organizations

This section proposes a general procedure aimed at improving the sustainable management of information technologies and systems in organizations. The procedure is structured in five stages as shown in Fig 1.

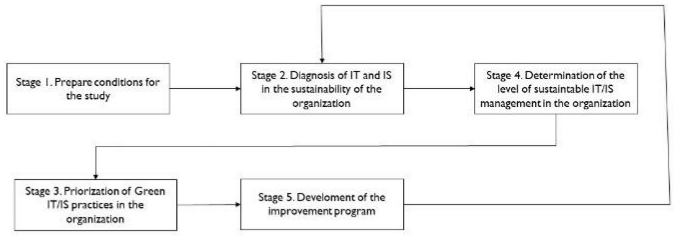

Fig 1. General procedure for the sustainable management of information technologies and systems in an IT project.

A. Stage 1. Preparation of the conditions for the study

This stage emphasizes the importance of securing strong commitments from top management, ensuring reliable access to information, providing thorough staff training, and fostering a supportive organizational climate. Before beginning the implementation, organizations must meet a set of essential preconditions, with each variable needing to be evaluated as acceptable. The author identifies the key premises necessary for the procedure's successful application:

1. Organizational Commitment: The willingness of top management and other key members of the organization to actively support and implement the procedure.
2. Reliable and Accessible Information: Ensuring that the necessary information is both accessible and sourced from reliable channels.
3. Staff Training: The staff involved in implementing the procedure must be well-trained and knowledgeable in technology management and information systems.
4. Organizational Climate: A positive organizational climate that promotes teamwork, collaboration, and staff motivation is crucial for successful implementation.

B. Stage 2. Diagnosis of IT and IS in the sustainability of the organization.

This stage involves a comprehensive diagnosis of information technologies and systems concerning sustainability, focusing on key dimensions such as Sustainable Use, Sustainable Procurement, Sustainable Manufacturing and Development, Sustainable Design, and Sustainable Governance. The proposed approach recommends conducting this diagnosis by evaluating IT and IS management in alignment with the dimensions identified in the bibliographic review conducted within the Theoretical Reference Framework. These dimensions, as outlined in the study, provide a structured foundation for assessing the sustainable management of information technologies and systems, as summarized in Table II.

Table II. Dimensions associated with the sustainable management of information technologies and systems

Dimensions	Conceptualization
Sustainable Use	It refers to the use of technological devices and other information systems or technologies in an

	environmentally sound manner in terms of reducing energy consumption.
Sustainable procurement	It is associated with the acquisition of ecological products, materials, components or technologies adjusted to environmental standards or indicators, thus reducing the generation of unsafe chemical products. It also includes the monitoring of suppliers and their compliance with social and environmental aspects.
Manufacturing and sustainable development	It takes into account the manufacturing of electronic components, computers, and other associated subsystems with minimal or no impact on the environment. It also includes process automation, implementation of intelligent technologies and dematerialization initiatives.
Sustainable design	It refers to the design of energy-efficient and environmentally sound components, servers and cooling equipment.
Reuse, recycling and waste	Includes refurbishment and reuse of obsolete computers and other electronic equipment to reduce the purchase of new components, resource depletion and pollution.
Sustainable government	It includes the incorporation of objectives and indicators that contribute to sustainability in the strategy. In addition, it takes into account the design of strategies and the formation of ethical values in the organization.

C. Stage 3. Prioritization of Green IT/IS practices in the organization.

At this stage, the author proposes a specific procedure for prioritizing Sustainable Information Systems and Technologies (Green IT/IS) practices or initiatives, utilizing the TODIM (Multi-Criteria Interactive Decision Making) method [14]. Green IT/IS practices are evaluated based on their maximum impact on the economy (Eco), society (Soc), and ecology (Ecol), following the "Triple Bottom Line" (TBL) model—one of the most influential frameworks for sustainable development. Additionally, the evaluation considers the impact of these practices on the organization's Strategic Objectives (SO) and Processes (P), as illustrated in equation (1).

$$Green\ ITIS\ Practice = f(\max(Eco, Soc, Ecol), OE, P) \quad (1)$$

To prioritize each practice, the equation set proposed by [25] for the TODIM method is applied. The process begins by calculating the dominance measure of practice i over Green IT/IS practice j for each decision criterion, as shown in equation (2):

$$\phi_c(i,j) = \begin{cases} \sqrt{\dfrac{a_{rc}(W_{ic} - W_{jc})}{\sum_{c=1}^{m} a_{rc}}} & (W_{ic} - W_{jc}) > 0 \\ 0 & (W_{ic} - W_{jc}) = 0 \\ -\dfrac{1}{\theta}\sqrt{\dfrac{(\sum_{c=1}^{m} a_{rc})(W_{ic} - W_{jc})}{a_{rc}}} & (W_{ic} - W_{jc}) < 0 \end{cases} \quad (2)$$

Where:

$\phi_c(i,j)$: Represents the dominance index of practice i over practice j with respect to decision criterion c.

a_{rc}: Indicates the substitution rate or trade-off ratio between criteria r and c.

$W_{ic} - W_{jc}$: Represent the value functions or weights assigned to practices i and j for criterion cc.

θ: Represents the loss attenuation factor.

These variables are crucial for the decision-making process and for determining the overall dominance measure of each practice. The application of ϕc(i,j), arc, Wic−Wjc, and θ facilitates a detailed assessment of practices by considering their relative significance, their impact on the decision criteria, and the extent to which one practice dominates another in relation to specific criteria. The overall dominance measure of practice i over practice j with respect to criterion c is then computed using equation (3):

$$\delta(i,j) = \sum_{c=1}^{m} \phi_c(i,j), \qquad \forall (i,j) \quad (3)$$

Where:

$\delta(i,j)$: Represents the measure of dominance of practice i over practice j.

Finally, the overall prospective value (ξi) of each practice is determined by aggregating the dominance measures across all criteria. This calculation is performed using equation (4), which incorporates the comprehensive evaluation of each practice considering its performance across various criteria and the relative importance of those criteria. This overall prospective value reflects the practice's overall effectiveness and suitability in the context of the decision-making process.

$$\xi_i = \frac{\sum_{j=1}^{n} \delta(i,j) - min \sum_{j=1}^{n} \delta(i,j)}{max \sum_{j=1}^{n} \delta(i,j) - min \sum_{j=1}^{n} \delta(i,j)} \quad (4)$$

The resulting ξi provides a normalized measure, enabling decision-makers to rank or prioritize each alternative based on the decision criteria. With ξi scaled between 0 and 1, it offers a clear perspective on the relative strengths of different alternatives within the decision-making process. The overall prospective value of each alternative falls within the interval 0≤ξi≤1, where a higher value indicates a stronger overall performance relative to the criteria being evaluated.

D. Stage 4. Determination of the level of sustainability in IT/IS management.

Compensatory fuzzy logic is employed at this stage to model the organization's sustainability level in IT/IS management by incorporating various dimensions and practices. This phase involves both formulating the verbal expressions of the fuzzy logic model designed to evaluate the Green IT/IS level within an organization and translating these expressions into predicate calculus [26]. The research defines the following primary predicate:

An organization x is considered to have a high level of sustainability in IT/IS management if the following conditions are met: 1) there is a high degree of sustainable procurement, 2) a high degree of sustainable design, 3) a high level of sustainable development and manufacturing, 4) a high degree of sustainable use, and 5) high control over reuse and recycling. Based on these criteria, the composite predicate can be modeled as described in equation (5) below:

$$N_{Green\ IT/IS} = AS(x) \wedge DS(x) \wedge DFS(x) \wedge US(x) \wedge GS(x) \wedge CRR(x) \quad (5)$$

In the context of the fuzzy logic model for evaluating sustainability in IT/IS management, the following notations are used:

AS: Represents the truth value of the sustainable procurement level within the organization.
DS: Signifies the truth value of the sustainable design level within the organization.
DF: Denotes the truth value of the sustainable development and manufacturing level within the organization.
US: Represents the truth value of the sustainable use level within the organization.
GS: Indicates the truth value of the sustainable governance level within the organization.
CRR: Signifies the truth value of the level of control over reuse and recycling within the organization.

These variables are utilized to quantify the degree or extent to which various dimensions of sustainability are present or achieved within the organization. They function as truth values, offering a qualitative measure of the organization's performance in adhering to sustainable practices across different areas such as procurement, design, development and manufacturing, use, governance, and control of reuse and recycling.

Based on the primary predicate and the associated Green IT/IS practices for each dimension, a set of secondary predicates is defined. Exponents 2 and 3 are used to model the terms "very strong" and "hyper," respectively, while the exponent ½ is used to model terms such as "somewhat" or "more or less." These predicates are represented in a fuzzy tree structure to facilitate the evaluation of sustainability levels in the management of information technologies and systems within the organization. This approach provides a nuanced assessment of how well the organization meets its sustainability objectives in various dimensions.

E. Stage 5. Preparation of the improvement program

The objective of this stage is to develop an improvement plan aimed at addressing and enhancing areas with the poorest evaluations. This involves identifying the practices and dimensions that received the lowest scores and devising targeted actions to improve them. The work team is responsible for pinpointing the primary issues and their underlying causes.

To facilitate this process, it is recommended to use various tools and techniques for problem identification and prioritization, such as Cause and Effect diagrams (also known as Fishbone diagrams), Pareto analysis, and other relevant methods. These tools help in systematically analyzing the problems and determining their root causes.
The improvement plan should encompass several key components:

1. Dimension : The specific sustainability dimension being addressed.
2. Green IT/IS Practice : The particular practice or initiative related to Green IT/IS that requires improvement.
3. Improvement Actions : The specific steps or interventions planned to enhance the identified practice.
4. Impact on Objectives and Processes : The expected effects of the improvement actions on organizational goals and processes.
5. Execution Time : The timeline for implementing the improvement actions.
6. Responsible Parties : The individuals or teams assigned to carry out the improvement actions.
7. Participants : Key stakeholders involved in or affected by the improvement actions.
8. Date : The target date for completing the implementation of the improvement actions.

This structured approach ensures that all relevant aspects are considered, and that the improvement efforts are effectively managed and executed.

IV. Results of the Application of the General Procedure

This section presents the key results from evaluating sustainability in the management of information technologies and systems within an IT products and services company. Seven members, including project managers, were chosen for this assessment. Their responsibilities involved assigning weights, defining criteria, and selecting various elements of the procedure. A survey was developed and administered to assess IT and IS sustainability in the organization. The results are summarized based on the average scores from the members’ responses to each question.The survey revealed that the lowest scores were associated with the acquisition of green products, the manufacture of environmentally friendly components and services, equipment recycling, and the development of sustainability strategies. Table III presents the practices selected for the Sustainable Use dimension, offering an overview of the specific practices evaluated and their related sustainability measures within the organization.

Table III. Practices selected for the Sustainable Use dimension

No	Green IT/IS Practice	Code
1	Use of modern UPS in Data Centers	Uso_UPS
2	Use of laptops	Uso_comp_port
3	Configuration of Energy Management features in the equipment and systems.	Conf_energ
4	Cloud computing	Comp_nube
5	Use of videoconferencing, virtual meetings, teleworking and distance learning	Pract_trab_remoto
6	Double-sided printing, document scanning and digital signature	Impres_digit
7	Installation of thin clients	Inst_cliente_lig
8	Implementation of an energy management system	Sist_imple_energ
9	Sharing multifunction printers on the network	Comp_impr
10	Use of LED technology	Utiliz_LED

The weight (ωj) of each criterion was determined using Saaty's Method, a systematic approach that relies on paired comparisons to assess the relative importance of different criteria. The work team conducted these comparisons, utilizing a numerical scale to express how many times one criterion is more significant than another. The consistency of these judgments was evaluated by calculating the inconsistency coefficient (CI), which was found to be less than 0.10. This low CI value indicates a high level of consistency among the team members, ensuring that the weight assignments accurately reflect the collective judgment.

Finally, the overall prospective value (ξi) of each alternative was calculated using equation (4), as presented in Table 3. The ξi values allow decision-makers to rank or prioritize each of the Green IT/IS practices identified within the Sustainable Use dimension. Table IV displays the overall prospective value for each practice in the Sustainable Use dimension, providing a clear basis for prioritization.

Table IV. Prospective value of each practice of the Sustainable Use dimension.

Green IT/IS Practice	ξ_i	Order
Uso_UPS	0.69692383	5
Uso_comp_port	0.72615053	4
Conf_energ	0	10
Comp_nube	0.60566604	8
Pract_trab_remoto	1	1
Impres_digit	0.62739896	7
Inst_cliente_lig	0.59823264	9
Sist_imple_energ	0.66808298	6
Comp_impr	0.8033047	3
Utiliz_LED	0.80921995	2

The process of prioritizing Green IT/IS practices is systematically applied to each of the defined dimensions, ensuring a comprehensive evaluation across all relevant areas. This structured approach allows for a consistent assessment and prioritization of practices within each dimension, leading to more informed decision-making and effective implementation of sustainable initiatives.

Table V. Summary of Prioritized Criteria by Dimension in Sustainable IT/IS Management.

Dimension	Associated measurement criteria
Sustainable Procurement (AS)	CM1: monitoring of environmental actions. CM2: environmental requirements for suppliers. CM3: purchase of green supplies.
Sustainable Design (DS)	CM4: network virtualization. CM5: installation of smart switches. CM6: energy efficient processors. CM7: monitoring the energy consumption of servers.
Sustainable Use (US)	CM8: systems to optimize energy supply. CM9: hardware reduction. CM10: use of videoconferencing CM11: virtual meetings, teleworking CM12: distance learning internships. CM13: use of digital signature.
Manufacturing and Sustainable Development (FDS)	CM14: practices related to cloud computing CM15: process automation. CM16: document management systems.
Sustainable Government (GS)	CM17: management of information technologies and systems. CM18: IT hardware inventory. CM19: Green IT/IS strategy.
Reuse, Recycling and Waste (CRR)	CM20: recycling and reuse of hardware. CM21: e-waste management.

Table V summarizes the criteria associated with each dimension after prioritization, highlighting the key areas for improvement and those performing well in the organization's sustainable information technologies and systems management.

The evaluation process utilizes a fuzzy tree to represent the predicate logic, which is designed to assess the level of sustainability in the management of information technologies and systems within an organization. This fuzzy tree, as illustrated in Fig 2, provides a visual representation of the logical relationships between the various predicates used to evaluate Green IT/IS levels.

The overall sustainability level in the management of technologies and information systems was calculated, with a Green IT/IS level of 0.5181. Among the evaluated dimensions, Recycling and Waste Control emerged as the best-performing area, reflecting the organization's strong commitment to managing e-waste and promoting recycling practices. Conversely, the dimensions of Design and Sustainable Governance received the lowest scores, indicating areas where the organization has significant opportunities for improvement.

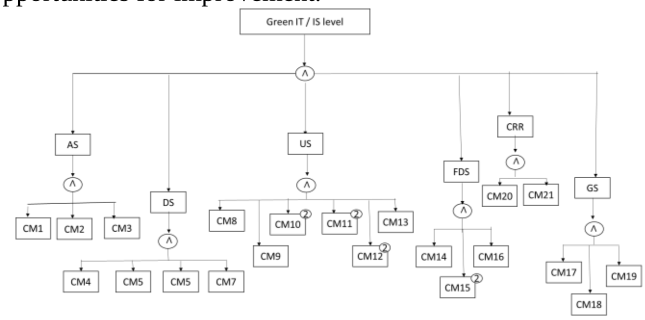

Fig. 2. Logical Tree Representation of predicates to evaluate the level of Green IT/IS.

This detailed analysis highlights the strengths and weaknesses across different sustainability dimensions, providing a clear roadmap for targeted improvements. By addressing the lower-scoring dimensions, such as Design and Sustainable Governance, the organization can enhance its overall sustainability performance, aligning its IT/IS practices more closely with its strategic environmental goals. This iterative process of evaluation and prioritization ensures that the organization continuously refines and optimizes its approach to managing sustainable information technologies and systems.

In this context, the criteria that received the lowest evaluations within the organization were those associated with the installation of intelligent switches, the deployment of free cooling systems, the implementation of smart technologies, the adoption of green technology, and the management of Green IT/IS strategies. These areas represent significant challenges and opportunities for improvement.

On the other hand, the criteria that scored the highest were those related to hardware reduction and reuse, product life cycle estimation, and e-waste management. These results indicate that the organization is performing well in minimizing resource usage, extending the life of IT products, and effectively managing electronic waste, all of which are critical aspects of sustainable IT/IS practices. This strong performance in these areas suggests a solid foundation for further sustainability initiatives.

To optimize and streamline the procedure, the author developed a specialized software tool. This system was created using C++ in the Qt Creator development environment, with SQLite selected as the database management system for its robustness and efficiency.

The software tool features an intuitive interface for entering essential parameters, including alternatives, criteria, and expert inputs, which are crucial for executing the procedure effectively. Fig 3 displays the window for inputting initial parameters. This window is designed to facilitate user interaction by providing clear fields for entering the necessary data.

In addition to parameter entry, the tool includes several advanced functionalities to enhance its utility. Users can view results directly within the application, export them to PDF for comprehensive reporting, print them for physical documentation, and easily open or save data as required.

To address the identified weaknesses, the team then developed targeted improvement plans focused on enhancing the organization's performance in the lower-scoring areas. These plans aim to bolster the organization's overall sustainability by implementing measures that address the gaps in smart technology deployment, energy-efficient systems, and strategic management of Green IT/IS initiatives. Through these focused improvements, the organization seeks to achieve a more balanced and robust approach to sustainable information technology and systems management.

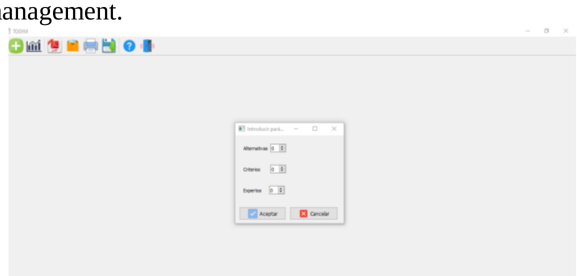

Fig. 3. Window for inputting initial parameters.

The software includes an option for inputting evaluations provided by experts. These experts are responsible for assessing each Green IT/IS practice according to the specified criteria. The system has built-in functionality to check the consistency among experts' evaluations. Consistency is verified when the inconsistency coefficient (CI) of the experts' judgments is less than 0.10, indicating reliable agreement among the experts.

Once the procedure is completed, the system presents a results window that displays the alternatives ranked by their overall prospective value and General Sustainability Level. This interface provides a clear and organized view of the results, enabling users to easily interpret and analyze the prioritization of Green IT/IS practices based on the evaluated criteria.

V. Conclusion

The analysis of existing knowledge and practices for constructing the theoretical-referential framework revealed that, despite numerous recent studies focusing on incorporating sustainability into IT/IS management, there is a notable lack of integrated approaches that consider the full life cycle of IT and IS. The proposed general procedure offers a viable alternative for advancing sustainable management of information technologies and systems. It draws on contemporary theories, frameworks, and practices related to Green IT/IS, while also addressing the specific needs of Cuban project-oriented organizations.

Incorporating specific procedures for prioritizing Green IT/IS practices, calculating weight allocations, and assessing the level of Green IT/IS within an organization, the procedure provides a robust methodological tool for enhancing sustainability in IT/IS management. The prospective validation by experts has demonstrated the procedure's feasibility, viability, and methodological soundness, indicating its strong alignment with real-world applications and its suitability for Cuban IT project-oriented entities.

The practical application of the procedure in an IT project-oriented organization highlighted key dimensions and variables impacting sustainable IT/IS management performance. This has laid the foundation for developing an improvement action plan aimed at evaluating and enhancing sustainability levels. Additionally, the software application significantly optimizes the evaluation process for Green IT/IS practices by automating complex tasks. Developed with C++ using Qt Creator and SQLite, it effectively manages input parameters, evaluates expert consistency, and presents results through an intuitive interface.

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Jose Manuel Lamis Rivero, PhD student in the Department of Infocommunication Technologies at the National University of Science and Technology MISIS and a Master in Project Management from the University of Computer Sciences (UCI), he brings a deep expertise to their role as a Principal Specialist at the Department of Informatization, Cuban Ministry of Higher Education. Their research focuses on organizational sustainability, IT project management, and artificial intelligence.

Alexey Zherdev, Associate Professor of the Department of Infocommunication Technologies in the National University of Science and Technology MISIS and CTO at Human Technologies Laboratory (HT Lab). Associate Professor Zherdev's researches focus on the personnel assessment software development, ERP systems, big data, ETL and he is known as one of the authors of HR Platform Maintest. Additionally, he had researches in the acoustic spirometry area and publications in such journals as Mining Information and Analytical bulletin.

Juan Antonio Plasencia Soler, Full Professor and Doctor in Technical Sciences in the Department of Organizational Management of the University of Computer Sciences (UCI). His research is focused on corporate sustainability, education for the Sustainable Development Goals and the management of green technologies and information systems. He has published more than 20 scientific articles in international scientific journals.