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A Sustainable Things Proposed Method Using Green Information Technology

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Abstract

The topic of sustainability has received a lot of attention in recent years, particularly in relation to solutions that aim to prolong the life of the planet's natural resources. In addition, the ongoing development of information technology is a crucial concern (IT), which results in a great environmental impact. Things or higher education institutions, like any other institution, generate impacts on the environment, whether from IT or any other nature. In this sense, one of the concepts that can be introduced in the search for sustainability at the university is Green IT. Thus, this work aims to propose an approach for the possible implementation of Green IT in things, taking into account the practices and approaches that already exist and are presented by the literature available in selected databases. This model was created from a scoping study and the construction of a conceptual framework. The result achieved was the proposed conceptual framework called Green IT Adoption Process in Higher Education (GITAPHE), based on three main constructs: Context, Readiness and Adoption.

Keywords: Green IT; ICT Green; Green Computing; Sustainable things

1. Introduction

The constant evolution of information technology (IT) results in a large volume of electronic waste and higher energy consumption for processing information systems, among other things. [1]. This is intensified by the issue of planned obsolescence, which increases the potential environmental impacts of IT. The constant evolution of information technology (IT) results in a large volume of electronic waste and increased energy consumption for processing information systems, among other things [2]. This is exacerbated by the issue of programmed obsolescence, which increases the potential environmental impacts of IT. Thus, one concept that can be incorporated into the search for sustainable things is Green IT, or Green Information Technology (GIT), which, according to Murugesan and Gangadharan (2012) [3], is a broad term that encompasses technologies, information, and environmentally sound practices. Because things deal with information technology on a daily basis, it is possible to apply Green IT concepts to the development of a more sustainable campus. Thus, the fact that GIT is being implemented in the daily life of the university can serve as an example or incentive for the most diverse types of organisations, as well as raise awareness among future professionals in training. As a result, students' awareness of Green IT can be expected to shape IT practises in organisations in the future. It is critical that these actions be implemented in things by raising academic community awareness, energy management, proper disposal of electronic waste, or even contracting with suppliers who have green seals [4]. This shift in consciousness occurs directly through Green IT teaching, research, and extension, so it is also necessary to train teachers, technicians, and institutions on the importance and practice of sustainability in IT. As a result, it is possible to improve academic knowledge development by identifying mechanisms, methodologies, and/or practices that facilitate the understanding and dissemination of these concepts in the business environment.

1.1 The Green Information Technology Concept

Green IT is a global movement toward more effective and efficient organisational and national strategies and policies [5]. Murugesan and Gangadharan (2012) [3] define green IT as the development and use of hardware, software, and information systems devices with minimal environmental impact; using IT to support other environmental initiatives; and using IT to raise awareness to promote sustainable initiatives.

OECD [6] proposes a Green IT framework based on three types of IT impacts: first-order impacts, which involve direct, positive and negative effects due to IT goods and services; second-order impacts, which arise from IT applications that reduce environmental impacts on economic and social activities; and third-order impacts, which are related to behavioural, process, and telecommunications issues.

Green IT seeks economic viability while improving system performance and usability, according to Murugesan (2008) [4]. GIT combines environmental sustainability, energy efficiency economics, and total cost of ownership, including disposal and recycling. Dias (2015) [7] examines things' green practices. The author linked these practices to responsible managers' environmental beliefs and institutional pressures in her work. The study found a lack of Green IT knowledge and communication between society and higher education institutions. Few managers followed normative instructions for sustainable practice actions because they were only suggestions. Academics must pay more attention to standardisation and resulting practices.

The constructs were chosen using research hypotheses, previous studies, and interviews with a variety of sources. Four hypotheses are used in this study [8]:

- H1: government regulations influence higher education's management style in the application of green computing;
- H2: government regulations influence the implementation of tools and technologies to support green computing in higher education;
- H3: management style influences successful adoption of green computing in higher education;
- H4: tools and supporting technologies influence the successful adoption of green computing in higher education (hardware and software).

The successful adoption of green computing is primarily indicated by the energy efficiency and hardware efficiency of Information and Communication Technology, based on the constructs and hypotheses of the relationship between them (ICT).

Using these frameworks (or models), the idea of implementing Green IT in higher education institutions as part of the solution to becoming a sustainable university can be conceived. This proposition's literature may be extensive, so it should be researched further, especially in Green IT. For consistency, the research methodology was based on the construction of a framework, supported by a scoping study of Green IT strategies, practices, and policies in things.

2. Methodology

2.1 *Approach method*

The hypothetical-deductive method was used in this work. Conjectures, solutions, or hypotheses are formed based on the perception of problems, gaps, or contradictions in previously existing knowledge. According to the research findings, these are either falsified or corroborated.

Popper (2002) [9] describes the hypothetical-deductive method in four steps: expectations, problem, conjectures, and falsification. Disagreements with existing theories are the problem. The proposed solution is a new conjecture, and falsification tests involve observation and experimentation. This work hypothesised that a university could become more sustainable by adopting Green IT based on existing practices.

The constant evolution of information technology (IT) results in a large volume of electronic waste and higher

2.2 Methods of Procedure

The use of a qualitative approach was primarily considered due to the nature of the data. This is distinguished by a focus on subjective interpretation, evidence from multiple sources, and the design of the environment in the context of the research, in addition to the researcher's familiarity with the phenomenon under investigation, among other things. In terms of purpose, this work is classified as strategic basic research, which is defined as work that aims to acquire new knowledge in broad areas and solve recognised practical problems. It is typically created with a great deal of formalisation and objective generalisation [10].

In terms of broader implications, this research is classified as descriptive, with the primary goal of describing the characteristics of specific phenomena. The use of standardised techniques in data collection is quite significant.

This work was developed using the following methods: According to Jabareen (2009) [11], the conceptual framework construction consists of eight phases; the scoping study consists of five steps that are part of the framework construction's third phase.

2.3 *Phases of conceptual framework development*

The first phase, "mapping the sources of selected data" involves mapping the multidisciplinary literature on the phenomenon in question to match text types and other sources with existing empirical data and practices.

CiteSpace® version 5.4 R4 is a Java-based application for visualising and analysing scientific literature. First, the study mapped the Green IT scenario.

The second phase involves reading and categorising selected data by discipline. This phase involved a literature review (aided by the first phase's findings) to identify Green IT and sustainable university practices.

Read and reread data in Phase 3 to understand competing or contradictory concepts. A literature review and scoping procedure were used to outline the research area's extent, scope, and nature during this phase. There are five steps involved. The process includes the research question, relevant studies, study selection, data mapping, grouping, summarising, and reporting. This phase produces studies that answer the research question and are organised according to their purpose, main findings, and how the university context was applied or discussed. Phase 4 identified each concept's main attributes, characteristics, assumptions, and functions. The second and third specific objectives of this work were consolidated at the end of this phase: identifying and selecting Green IT strategies, practices, and policies applied to things, as well as other Green IT and sustainability approaches applied to things that contribute to the development of this proposal. We grouped similar concepts in Phase 5 and began relating them for Phase 6, synthesis, resynthesis, and meaning construction, building the framework from all conceptual delimitation developed up to that point. The outcome of this phase increased the previous goal. Because the proposal focuses on model construction, phases 7 and 8 did not occur in this work. The outcomes of the six phases consolidated the work's goal.

Figure 1 summarises the sequence of research procedures using the hypothetical-deductive method and the six phases of framework construction.

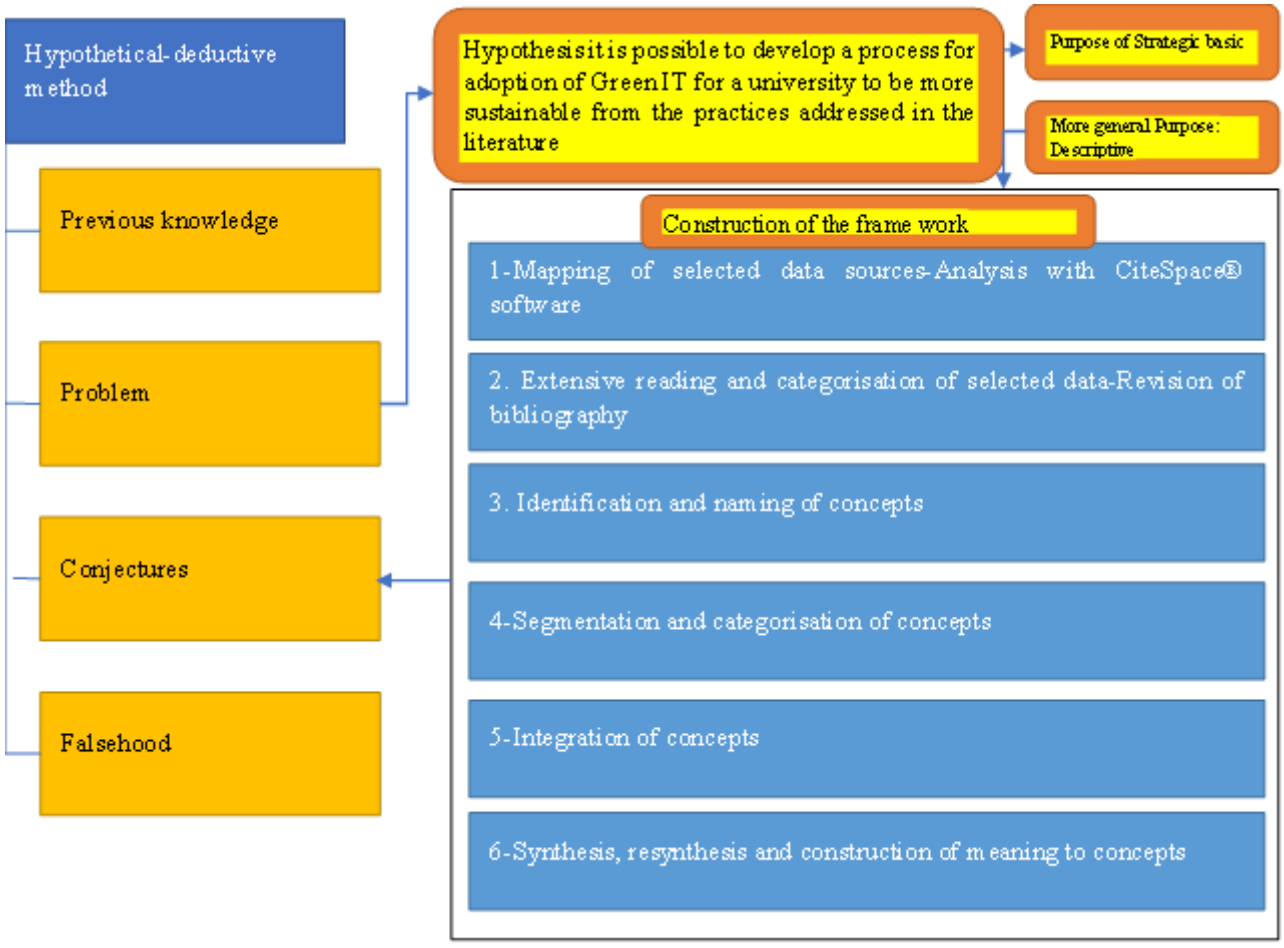

Figure 1: Summary of the survey methodology.

The hypothetical-deductive approach method is divided into prior knowledge, problem, conjectures and falsehood. The research problem gives rise to a hypothesis, which needs to be tested from two procedural methods. Immediately, the research conjectures arise that will allow corroborating or refuting the initially elaborated hypothesis. Finally, the conclusions of the study are raised. The coming sections highlight the realisation of the six research phases (from

mapping to creation of the framework), as presented in Figure 1.

3 Construction of the Conceptual Framework

3.1 Mapping of selected data sources

For this phase, CiteSpace® was used, which has an interface with Web of Science® and Scopus®. To begin this mapping, a database was needed, so the keyword green IT was used.

The time period of the analysis was limited to 2000 to 2021, as there were few publications before that. The Web of Science® database found 571 congress papers, book chapters, and journal articles. Scopus® found 1,250.

The databases were then applied to CiteSpace®, creating a project for each and analysing them separately to avoid duplication. The projects were analysed from three perspectives: main application countries, common keywords, and frequent bibliographic references. Regarding Green IT application countries, the US, Germany, Malaysia, Indonesia, China, Japan, South Korea, and India were more relevant. The US has many and older discussions, while Malaysia and Indonesia have more recent ones. These countries can be used to evaluate regulations and institutional practices in place and/or in progress.

Concerning the most common keywords, a classification was performed and similarities were identified to classify them into five groups classified as (i) Green IT and synonyms ; (ii) Generic sustainability terms ; (iii) Technology and information system; (iv)management and strategy and (v) Green IT Niches The identification of the relevant keywords within the theme of GIT served to understand better the main terms referring to the area, in order to guide the next research movements, both for the construction of knowledge and for the use of these terms in new searches. This phase, therefore, served to identify some of the main characteristics inherent to the available literature on Green IT to guide the next research movements. In the next phase, the theoretical implications arising from the literature review that characterise the process of adopting the Green IT were discussed.

3.2 Extensive reading and categorisation of selected data [12]

From the mapping of the data and the consequent more in-depth bibliographic review on Green IT and sustainable practices in things, extensive reading of this information was carried out; literature analysis was carried out in order to seek patterns and categorisation in the most relevant constructs of the theme. As a result, ten constructs were initially defined, listed below:

i. Adoption: movement and intention to adopt or the adoption itself of Green IT practices;
ii. Awareness: Awareness of the academic community in relation to Green IT;
iii. Context: the context in which the university is inserted in relation to Green IT (technological, organisational and environmental);
iv. Teaching and research: undergraduate and graduate programs, research projects, and courses, among other educational and partnership initiatives that cover Green IT;
v. Hardware and Software: sustainable hardware technologies and software applications, whether in their design and use, or in support of initiatives of this nature;
vi. Metrics: indicators and various metrics to quantify the efficiency of Green IT initiatives;
vii. Motivators: motivating factors for adoption of Green IT (economic, regulatory and ethical);
viii. Readiness: dimensioning of how ready the institution is for adopting Green IT or implementing its practices;
ix. Management System: system aimed at managing Green IT strategies, practices and policies across the university;
x. Organisational Support: initiative and support from the university leadership in relation to the adoption of Green IT in an institutional way.

3.3 Identification and naming of concepts

The next move from the ten constructs developed in the previous phase was to identify the concepts they cover. For this, a scoping study was carried out to better structure these concepts and support them within practical and/or conceptual studies.

The first step of the scoping study was to identify which research question would help to find texts that address the application of Green IT concepts in things. So the question was: 'What strategies, practices, policies and other approaches to Green IT can be applied to things?'.

From this, studies were sought that could answer this question. Therefore, the second step was to start the process of identifying the relevant studies. This was done by choosing keywords that referred to the research topic and relevant databases in the area.

The chosen keywords, as well as the research question, have two strands, Green IT and university, and were defined as follows:

- Keywords that refer to Green IT: green it; green ICT; green computing; green information technology; greening it; greening ICT; greening computing; and greening information technology;

- Keywords that refer to the university: which aggregates both university and things) and higher education;
- All terms composed of two or more words were inserted with double quotes;
- The mix of keywords related to GIT and the university was made using logic.

For keyword searches, Engineering Village®, Scopus®, Science Direct®, Web of Science®, and Emerald Insight® were chosen. There were 3,422 results from these keyword-database combinations.

Third, select studies. Green IT discussion (publications) increased significantly after 2009, so this was the first selection criterion. Thus, 2,329 of 3,422 articles met this criterion, with 1,093 being excluded from the scope study list.

The 2,329 articles were then checked for duplication (showing up in multiple search results and/or databases). The study discovered 1,086 duplicate articles, leaving 1,243 articles.

The remaining 1,243 articles were then evaluated qualitatively based on their abstracts. Green IT strategies, practices, and policies in things were discussed empirically or conceptually in 291 works.

The full texts of the remaining 274 works were then searched. A thorough examination revealed that another 38 works did not respond to the research question, leaving 236. In the fourth step, these 236 works were thoroughly examined in terms of purpose and outcomes, and then classified according to the ten previously developed constructs: 27 for adoption, 27 for Awareness, 9 for Context, 37 for Teaching and Research, 67 for Hardware and Software, 17 for Metrics, 1 for Motivators, 2 for Readiness, 48 for Management System, and 1 for Organizational Support.

Step 5 discusses the relationship between the constructs in Section 4.4. It also goes over the foundations of the constructs and how these works contribute to the framework's pillars and construction.

3.4 Segmentation and categorisation of concepts

In this phase, the ten constructs were better detailed from the works that converged to the practices of each one of them. Three other relevant constructs were found for a Green IT adoption process: Green Buildings, Subjective Norms and Regulations. This resulted in a total of thirteen constructs, so that these were the pillars for modeling the framework for adopting Green IT.

Another relevant point was the sequential aspect that these constructs naturally presented. Thus, it was possible to categorise them into three stages:

1) Current state assessment: Context; motivators; Subjective Norms; regulations;

2) Preparation for adoption: Awareness; Metrics; Readiness; and Organizational Support;

3) Implementation and maintenance: Adoption; Green Buildings; Teaching and research; Hardware and Software; and Management System.

3.5 Integration of concepts

Subtopics, definitions, and compositions To begin, the Context and Motivators constructs evaluate the organisation's forces (some internal, most external).

Economic, ethical, and regulatory drivers shape the technological, organisational, and environmental context. The environment is controlled. Within a company, ethical motivators are understood.

Contextual factors include technological, regulatory, organisational, and economic aspects. Because they resembled regulatory context, regulations and subjective norms were absorbed by context.

Readiness is comprised of attitude, technology, practice, policy, and governance. These dimensions are influenced by contextual factors. Attitude, Policy, Awareness, and Metrics are all components of governance.

Because the Organisational Support construct, along with a portion of the Awareness and Metrics constructs, was absorbed by the Readiness construct, their concepts were also associated with the Management System, because efficient management deals directly with organisational members adhering to proposed ideas and establishing performance metrics.

Adoption is linked to Management Systems, Hardware and Software, Green Buildings, and Teaching and Research, so they are Green IT strategies, practices, and policies.

Thus, the main constructs of the model were reduced to three, Context, Readiness and Adoption, and the others became concepts belonging to these main ones.

- Context: Motivators; Subjective Norms; and Regulations;
- Readiness: Awareness; Metrics; and Organizational Support;
- Adoption: Awareness; Metrics; Management system; Hardware and Software; Green Buildings; and Teaching and Research.

3.6 Synthesis, resynthesis and construction of meaning to concepts

In this phase, the associations between the concepts presented were consolidated, demonstrating the sequential and hierarchical relationships between them. The result of

this was called the Green IT Adoption Process in Higher Education (GITAPHE) [13], which can be visualised in the framework shown in Figure 2.

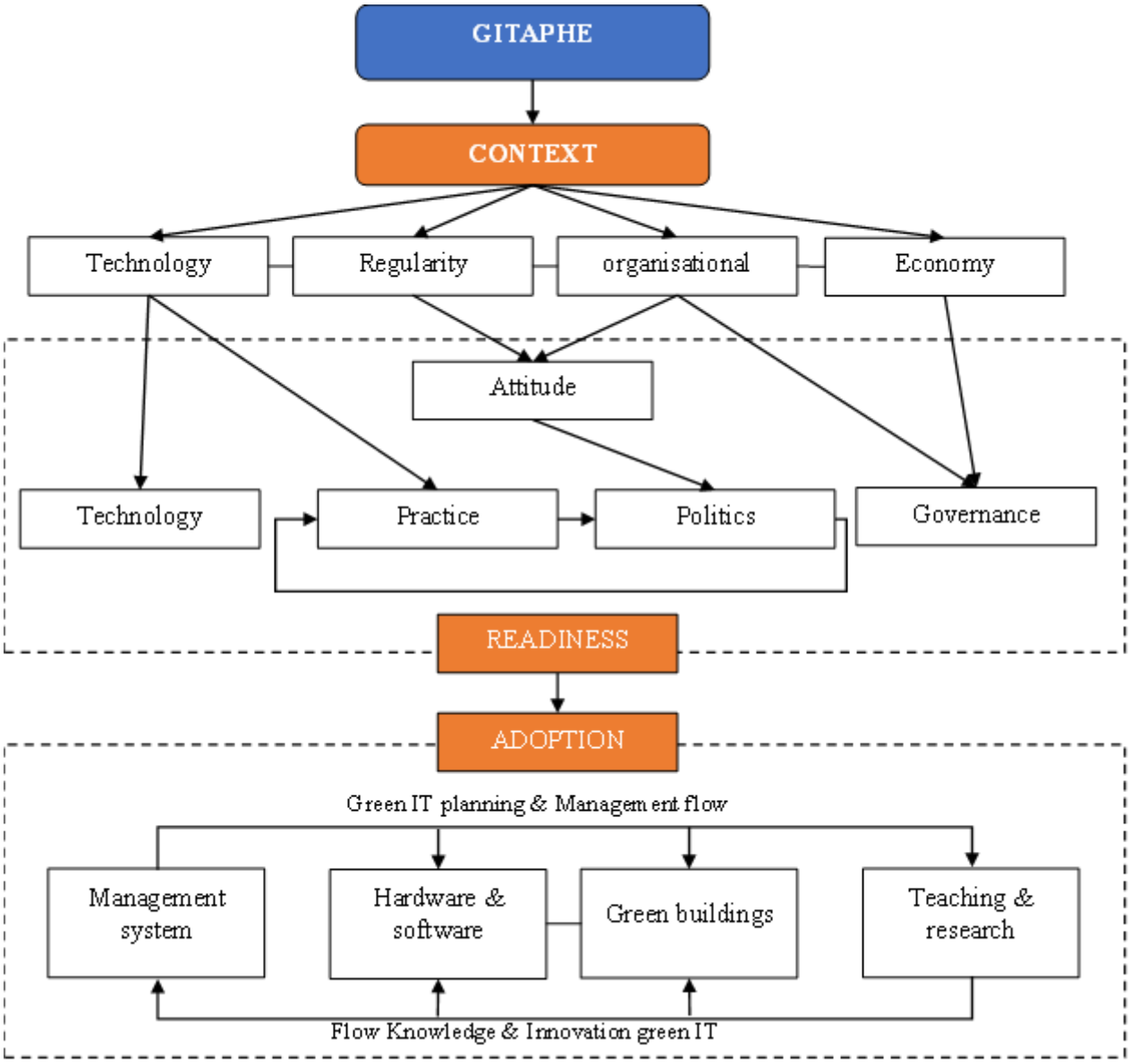

Figure 2 - Green IT Adoption Process in Higher Education (GITAPHE) (Designed by author)

First, the institution's technological, regulatory, organisational, and economic context must be evaluated. These similar motivators influence the assessment of the Readiness dimensions: attitude, technology, practice, policy, and governance.

Following an assessment of the Context and Readiness, we begin implementing Green IT strategies, practices, and policies via a Management System, efficient Hardware and Software, Green Buildings, and IT Green Teaching and Research programmes. This model sequences the Green IT adoption process at a university. The framework, foundation, and details of each concept presented and their theoretical and practical implications are examined and discussed in the following sections.

4. Results and Discussion

4.1 Green IT Adoption Process in Higher Education (GITAPHE)

GITAPHE is a model proposal for Green IT adoption made up of three sequential constructs (Figure 2). First, an institution's technological, regulatory, organisational, and

economic context must be examined. The institution's Readiness to Adopt Green IT is then assessed using its five dimensions. Finally, implement the adoption by implementing integrated and planned strategies, practices, and policies based on a management system, sustainable hardware and software, green buildings, teaching, and research for Green IT knowledge and innovation.

Table 1 presents the definition of the GITAPHE constructs: Context, Readiness and Adoption.

Table 1: Definition of GITAPHE constructs

Construct	**Definition**
Context	The current state of internal and external forces to the institution interfere and motivate the adoption of GIT. It has four factors: technological, regulatory, organisational and economic.
Readiness	It is the level of preparation and capacity that the institution has to adopt Green IT. It has five dimensions: attitude, technology, practice, policy and governance.
Adoption	It is the institution's adoption of Green IT strategies, practices and policies. It has four modalities: management system, hardware and soft ware, green buildings and teaching and research.

4.2 The Context and its factors

Context is defined as the current state of internal (how relevant people and leadership perceive it) and external (how important it is for the sector you are entering, available technologies, regulations and even economic viability) forces institution that interfere and motivate the adoption of GIT. Figure 2 shows Context and its four factors. For this work, the idea of context was merged with the idea of motivators, because their concepts, although some authors present them as two different things, present similarities and convergences. In a structured process of adopting Green IT, analysing the two separately can reveal some redundancy.

Therefore, the four factors that characterise the Green IT Context in higher education are defined as:

- **Technological:** the level of information technology available to the education sector and the depth to which other organisations in this sector implement these technologies.
- **Regulatory:** regulations and standards (mandatory or voluntary) in force in the place where the university operates, mainly regarding energy consumption and electronic waste disposal, and the government's maturity in dealing with the environmental issue.
- **Organisational:** level of corporate social responsibility, awareness of leadership and the academic community and how the university can deal with the importance of Green IT practices, from dealing with its suppliers to disposal.
- **Economic:** possibility of obtaining economic gains through cost reduction in the efficient use of IT resources, efficiency in energy consumption and even revenue gain through patents developed in research.

Some organisations operate in an advantageous technological environment because large IT organisations are under pressure to lower energy costs and increase installed technology efficiency [15]. The analysis is based on static variables, or the current state of these factors, as there are no tools for this type of analysis based on these four context factors. Considerations include current technologies, the regulatory environment, how things approach this topic, and how economically developed these systems and technologies are.

Therefore, as a first step towards adoption, some questions that can be asked to facilitate the understanding of these factors:

- Technological context: Are green information technologies available and/or implemented in higher education institutions in the region and worldwide? Is there any international benchmark in this type of implementation?
- Regulatory context: Are national and international regulations covering IT, sustainability and the university?
- Organisational context: Are there policies declared by the institution that cover Green IT and/or sustainability?
- Economic context: Is it understood by all the institution's stakeholders that there is economic feasibility in adopting Green IT strategies, practices and policies?

These questions are relevant to understanding the context in which the university is inserted, before moving on to the next step, the Readiness analysis.

4.3 Readiness and its dimensions

The ability of an organisation to adopt Green IT, including assets, resources, and processes for developing and managing infrastructure and people, is referred to as readiness. Readiness and context are distinct. Context refers to the internal and external forces that drive Green IT adoption, whereas Readiness refers to what the organisation has implemented or is planning to implement.

Although organisations with greater readiness are expected to lead Green IT adoption, those who are not prepared may face ethical and financial consequences [15]. In general, readiness can be divided into three categories: organisational; value network; and institutional [14]. Green IT adoption can be influenced by institutional readiness.

Attitude has an impact on the organisation's second Readiness dimension, policies. Given current regulations and leadership awareness of Green IT, policies that cover the entire life cycle of IT equipment and services are required. The strategic scope of the university can be viewed through three life cycle perspectives: 1) supply, such as electronic purchases, digital documents, server purchases, and so on; 2) operations and services focused on environmental impact, with energy management and equipment use policy; and 3) end of life, with collection, disposal, and/or recycling of unused devices and broken components [16]

Green IT policies and practices are inextricably linked. Policies are implemented through practices. According to Marcel (2016) [16], an organisation defines a policy, perceives it as a practice, and then improves the outcome based on experience, resulting in continuous improvement. The technological context is also crucial in defining these practices.

Suryawanshi, Narkhede, and Nirmala (2013) [17] present general practices for implementing Green IT in educational institutions, including: recycling and disposal of IT equipment; paper-reduction awareness; energy management for equipment; remote work or telework; and adoption of thin computing solutions. These practices reduce energy costs, carbon emissions, information technology waste, and regulatory compliance.

Green IT initiatives to prevent pollution, improve equipment stewardship, and implement clean technologies rely on management commitment, resource allocation, project management, and benefit tracking. According to Marcel (2016) [16], governance can be measured using the following indicators: clearly defined roles, structures, responsibilities, accountability, and control for Green IT initiatives; the presence of standards or procedures to guide development; and the availability of impact metrics. Readiness-G as a thinking, theoretical, and logical structure, and ZEN as an action-implementation checklist [16]. The author also introduces a sixth readiness dimension called value, which focuses on the institution's Green IT benefits. For this work, value is a result of good readiness in the other five dimensions because value comes from good governance, which comes from a good attitude, clear and well-defined policy, good practices, and adequate technological investment.

From this discussion on the readiness of things in Green IT, it is possible to define its five dimensions as follows:

- Attitude: awareness and care of the institution with the issue of GIT;
- Policy: institutional statement promoting Green IT practices;
- Practice: materialising the policy into concrete green IT actions;
- Technology: implementable Green IT components and systems;
- Governance: strategic forecasting, resource allocation, the establishment of metrics and development of processes and structures to support Green IT.

While context analysis enables a more thorough search for information and data, Readiness provides more accurate mapping of the institution seeking Green IT adoption. Understanding a university's readiness is a diagnostic of the institution's maturity in implementing strategies, practices, and policies.

Given this scenario, context analysis is the first step toward adoption, followed by GIT readiness analysis. Some questions can be asked to better understand the university level in all five dimensions.

- Attitude dimension: Is there any involvement of the current university leadership, whether business managers or IT managers, with the adoption of Green IT?
- Policy dimension: Is there a clear Green IT policy that covers the entire lifecycle of equipment and services?
- Practice dimension: Are there Green IT practices being applied at the university, even if in an isolated and/or non-formalised way?
- Technology dimension: Are green information technologies being developed or applied institutionalised or individualised way?
- Governance dimension: Is there any level of IT or institution governance to support the adoption of Green IT?

4.4 Adoption and its strategies, practices and policies

Adoption occurs after a context and readiness analysis. Third, green IT practices, policies, and strategies should be considered. Environmentally conscious executives do not always act [15]. According to Alkali et al. (2017), the following factors influence technology adoption: availability, perceived satisfaction, trust in the Internet and computers, organisational support, interaction, perceived risk, and social norms. Seven Green IT factors are listed by Suryawanshi and Narkhede (2014). optimal resource utilisation, stakeholder participation, renewable energy, energy conservation, institutional policy, and legislation. Green IT implementation advice is provided by Wabwoba et al. (2012) [18]. 1) Incompetence of senior management and the IT team has an impact on implementation success; 2) People must understand the situation in order to participate. Alkali et al. (2017) emphasise perceived usefulness and ease of use in their individual adoption model. Molla (2008) [15] goes into great detail about adoption. Deep adoption entails mastering one type of practice. According to Hanief et al., green IT saves energy and hardware. Based on a scope analysis of previous works, adoption proposes practices for implementing Green IT in a higher education institution.

Management, hardware/software, green buildings, and teaching/research are all areas of expertise. 4.2 depicts their friendship.

Green IT strategies, practices, and policies across modalities. A good management system allows for the planning and management of hardware, software, and green building technologies. Teaching and research disseminate knowledge and innovation to the other three modes, promoting integrated adoption.

4.4.1 Management system

A Green IT management system deals with the university's organisational structure, which helps adopt and maintain practices and policies. It should include energy management, a governance model, institutional strategies, responsible leadership, performance metrics, electronic waste disposal and recycling, and a community awareness programme. Table 2 shows the main components of a Green IT management system.

Table 2: Management System for Adoption of Green IT [14, 15, 16, 19]

Component	Description
Energy management	Development of an intelligent system for monitoring and managing electrical and electronic devices, aiming to optimise energy consumption.
Governance, strategy and leadership model	The development of a governance model aligned with the best practices of Green IT supports a well-defined, long-term strategy and conscious and active leadership.
performance metrics	Definition of university operational performance metrics related to Green IT, with the goal of raising the bar in rankings such as the UI GreenMetric, which evaluates infrastructure, gas emissions, waste treatment, energy consumption, water consumption, and sustainability education. Definition of university operational performance metrics in relation to Green IT, with the goal of improving rankings such as the GreenMetric, which assesses infrastructure, gas emissions, waste treatment, energy consumption, water consumption, and sustainability education.
Disposal and recycling system	Development of an intelligent disposal and recycling system, which is efficient in analysing the life cycle of IT equipment so that they are not disposed of in good conditions or improperly, or that they are directed to recycling when relevant.
awareness program	Development of an awareness program based on factors that influence individuals and the collective to adopt Green IT and using tools such as workshops, training, lectures and various activities for its dissemination.

Since IT components require electricity to operate, sustainability and energy issues are particularly sensitive to one another. Intelligent systems are being researched in the era of industry 4.0, big data, and the Internet of Things and can be used for effective energy management. A system that can measure and produce timely energy usage reports is necessary. An effective Green IT management system must take into account the entire life cycle of the products and services. This includes getting rid of any broken, unused, or outdated items. In order to understand the factors that influence the adoption of Green IT, the academic community and its surroundings must also be mobilised through a practical awareness programme.

4.4.2 Hardware and software

The second pillar is GIT's hardware and software. These technologies include data centres, server virtualisation, documents, energy-efficient computing, and network and computer lab equipment and applications.

Things have data centres (data centres). This technology necessitates proper infrastructure and consumes energy in proportion to its size and data volume. As a result, implementing GIT in things necessitates treating them in accordance with their importance.

Virtualisation is used in green IT in higher education as well. Virtual machine systems, cloud computing, and IT infrastructures can all help. Virtualisation can be used in a variety of situations and can even help data centres become more environmentally friendly (virtualised data centres).

Hardware and software can help a university's Green IT implementation. Energy-saving computers and virtual applications that can be used across the institution are examples of energy-efficient computing.

To implement this physical and virtual infrastructure, the institution's IT department must provide unrestricted support for the equipment's maintenance and management and the

network systems' energy consumption. This team must be aware of the importance of Green IT, as well as trained and equipped with technologies that can transform the institution's technological environment into an energy-efficient one.

Finally, computer labs are common in things (used in teaching practice, carrying out research, group activities, and Internet access, among others). These labs must also embrace Green IT.

4.4.3 Green buildings

Green buildings are another pillar of university Green IT adoption. They promote sustainability, energy efficiency, hardware, and software applications. They include green building technologies, renewable energy, green offices, libraries, and student housing.

Green building technologies make buildings more sustainable by focusing on energy or another environmental pillar. It is critical that they contribute to the adoption of Green IT in order to build a sustainable university.

Installations based on renewable energy, most commonly solar, with plates and panels to capture and distribute energy for institutional use are one option for green buildings. These items can help to support green student dorms, offices, and libraries.

The latter two are desktop computers, scanners, printers, and multifunctional copiers. Energy conservation and paper-saving printing are common in these settings. Digitising processes and documents can be a low-cost and effective Green IT solution.

4.4.4 Teaching and research

To complete the GIT adoption cycle, teaching and research programmes are required. These programmes seek to train and educate the academic community on the subject while developing innovative management methods, methodologies, tools, strategies, hardware, software, and green building technologies. Undergraduate, graduate, extension, or short-term courses, distance learning platforms (e-learning), research projects, partnerships with the productive sector and other external entities, and events to discuss the topic in-depth and with other institutions are examples of these programmes. Developing GIT-focused courses or incorporating GIT concepts into existing courses and disciplines is critical to GIT adoption. Depending on how these curricula are implemented, both cases can be valuable. This knowledge equips professionals with the means to spread these ideas. Short-term training courses, in addition to formal education models (undergraduate and postgraduate), can be used to raise academic and labour market awareness of green IT.

These undergraduate, postgraduate, or extension courses can be designed in the distance learning format (e-learning). While limited in comparison to more practical approaches, it is a viable alternative to hybrid (semi-present) or completely distant learning models.

The evolution of e-learning benefits more theoretical courses or those related to programming and software. This necessitates a deeper understanding of e-learning methods as well as the necessary infrastructure. When teaching and researching Green IT, it is critical to developing projects that can discuss, study, and develop methods, techniques, and innovations in these technologies and information and communication systems. This can improve the institution's knowledge and maturity, allowing for a more robust implementation. Green IT innovation and knowledge acquisition can also include organised society and the productive sector. Things are interested in this topic because it is not solely concerned with the environment, and these technologies result in cost savings and resource efficiency. This implementation has the potential to extend beyond the boundaries of the university.

4.5 Theoretical and practical implications of GITAPHE

We were able to categorise ideas and seek patterns for Green IT applications and sustainable practices in things by using the published literature's discussion framework, theories, and practices. The three main GITAPHE constructs are context, readiness, and adoption. GITAPHE is the result of a thorough review of the literature, categorisation of reported experiences, and framework development. This model investigated Green IT practices in higher education. None of the models examined address university-wide Green IT adoption. The literature, according to GITAPHE, is fragmented and generalist, presenting mostly mental models of adoption or abstract conjectures.

Molla (2008) [15] created one of the first adoption models for businesses in general (GITAM). Despite its more primitive and generic nature, it was useful in developing the Context and Readiness constructs because the author developed the sequential idea that connects them for adoption.

Molla, Cooper, and Pittayachawan delved deeper into the issue of readiness and are one of the most prominent GITAPHE references in the Readiness construct. The Readiness-G directly influenced the five readiness domains in this work. The concept integration analysis produced GITAPHE Context (and its factors) and Readiness (and its dimensions). There was no evidence of a sequential relationship between these two concepts in any of the studies. This is a model proposal for this work, based on the idea that the university's Context must be assessed before analysing its Readiness. Because it is an integrated process,

none of the other models sequences Context, Readiness, and Adoption. This work promotes debate over previously published strategies, procedures, and policies. Green IT and international databases made this possible. The research was conducted in the United States, Europe, Indonesia, China, Australia, and other regions. This has numerous applications. Context refers to the location of the university, Readiness refers to how well it can implement Green IT, and adoption refers to how it is implemented. Teaching and research contribute to the virtuous cycle of planning management and knowledge innovation. Every adoption procedure emphasises energy. The majority of scoping studies addressed this issue. This concept can be applied to Green IT because IT performs a technical function associated with energy generation or storage. IT efficiency translates into energy efficiency. Disposal and recycling deal with items that are no longer useful or functional. An intelligent system for disposing and recycling electronic products for management and operation will most likely use information systems and technologies, which can indirectly increase energy efficiency.

Although some authors [20] emphasise the importance of active leadership for successful adoption, the literature reviewed did not present successful experiments in this area (in IT, business, or top management), with a relevant budget, or in the formation of specific committees. In this case, there are positive and negative aspects to forming this type of committee: the positive side is having people dedicated to this purpose, interested in and working to deliver an integrated adoption; the negative side is that others who are not on the committee may not value or encourage this adoption because it is not their practical responsibility.

This issue must be thoroughly resolved using idealised principles, or adoption will be merely on paper. In this regard, the literature lacks successful examples of integrated Green IT adoption and institutional models with technological and management pillars, as the reports, either deal with the theme conceptually or through individualised practices (not linked to a larger policy). Green purchases are uncommon (supply). Energy Star-certified products are mentioned only in passing. More research is needed on this procurement process. This should be incorporated into a system's strategies and governance. GITAPHE compiled the most diverse higher education strategies, practices, and policies. Future implementations and studies can go into greater depth on each construct.

5. Conclusion

All of the goals of this project were met. In this sense, it is possible to speculate that the hypothesis developed for this work, that it is possible to develop a process of adopting GIT to make a university more sustainable, was confirmed. The GITAPHE model is composed of three major and sequential constructs. An adoption process must learn Context and Readiness before implementing Green IT strategies, practices, and policies. This work presented a compilation of strategies, practices, and policies that can be applied in this context, in addition to the structured and sequential process of adopting Green IT in higher education, known as GITAPHE. It can serve as a starting point for future research in this area, particularly for more in-depth information on each of the Adoption construct's modalities.

The practical contributions, in short, can be listed below:

- The proposition of a sequential process based on three constructs for the adoption of Green IT in higher education institutions.
- The suggestion of possible strategies, practices and policies for adopting Green IT in higher education.
- Regarding the theoretical contributions, the following can be mentioned:
- Association of the concepts of Green IT and sustainable university, seeking synergy between frameworks that propose implementations in these two aspects.
- Discussion about the importance of IT and sustainability in the most varied areas of higher education institutions.
- Context Construct and its four factors, merging with the concept of Motivators, in order to simplify the understanding of static conjunctural aspects, such as technological, regulatory, organisational and economic factors.
- Readiness construct and its five dimensions, based especially on the G-Readiness, but with an interrelationship between dimensions, such as the influence of attitude in policy and policy in practice.
- Influence of Context factors on Readiness dimensions.
- Adoption Construct and its four modalities, with the Management System responsible for the flow of planning and management of Green IT, Teaching and Research responsible for the flow of knowledge and innovation in Green IT. At the same time, Hardware and Software and Green Buildings are the pillars technological.

5.2 Research limitations

This research was limited to analysing a broad spectrum of the literature to assess the types of Green IT practices available to be implemented in a university in a way that sought to propose an integrated model of adoption of these practices through an analysis of patterns. This was possible through the first six steps of the methodology to build a conceptual framework structured in eight steps. Not all practices were addressed in a detailed and exhaustive way, but the experiences reported made it possible to comprehend abstract concepts of how to adopt Green IT in things.

5.3 Propositions for future research

Therefore, for future work, it is suggested to validate GITAPHE through all its constructs, factors, dimensions and modalities, that is, the implementation of the last two steps of the methodology of construction of the conceptual framework. An initial validation with specialists in Green IT, sustainable things and managers of higher education institutions can be carried out for primary calibration of the model. However, a more successful validation would be the proposition of a case study, or even multi-case, with the implementation of GITAPHE in its entirety.

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