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A decisional smart approach for the adoption of the IT green

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Abstract
The new IT governance practices have emerged to adopt a responsible attitude within the company to question its mode of operation, its mode of consumption and its relationship with every IT service. The objective of our research is to ensure that the functions of the company should follow the criteria of coherence and of consonance, in order to develop a corporate culture oriented toward the restoration of the environment, green IT. Knowing how to make information and communication technologies as a catalyst for sustainable development and deploying a specific green framework to the company by using the powers of the artificial intelligence are the aim of our proposed approach. According to the four ecological aspects, the proposed approach, firstly it diagnoses the maturity of the company by grouping the existing processes and the IT needs processes. Secondly it unifies all the processes by using a prototype process. Finally, it evaluates the company's processes by using a suite of performance indicators then it lists a set of the best ecological recommendations.

Keywords IT green · Green IS · Sustainable development (SD) · Artificial intelligence (AI) · Information and communication technologies (ICT)

1 Introduction

Each organization must be accountable for its actions and in particular for its environmental and social impacts, and act in full transparency by report on its activities, its stakeholders and more broadly to the Corporation (Ferraro and Hanauer 2014).

The functions of the enterprise are used in such a way as to develop a corporate culture oriented toward the preservation and the restoration of the environment.

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In this perspective, new practices are emerging within the information system (IS) management that encourage the adoption of a responsible attitude, aiming to question its mode of operation, its mode of consumption and its relation to the IT object. At the center of this new field of investigation, emerges a concept, that of "Green IT" or "Green IS" (Schmermbeck 2019).

The challenge is then to study the extent to which ICT can contribute to sustainable development (SD). Thus, along side a vision of the threats generated by ICT and in an effective conception of the role of IS by report to sustainability, some recognize a positive link between SD and SI (Nada and Elgelany 2014). In particular, they see ICT as the latest gift that can build more sustainable society and a new economy based on SD values.

The contribution of ICT to sustainability can be made either directly or indirectly, either by reducing their own impacts, or by enabling the reduction in the impacts of other economic activities through their use characteristics (dematerialisation, abolition of physical and temporal boundaries,…) (Ziemba 2019).

The goal of our research is how to create a specific green IT framework by using the powers of the artificial intelligence that allows ICT as a catalyst for sustainable development also it balances ICT as a problem and ICT as a solution.

2 State of the art

2.1 Sustainability of ICT

ICT is an imaginary tool that bring a positive transformations to organization. Here they give a speech that largely falls within the field of sustainable development: good communication between people and nations; reduced professional travel, paper consumption and material exchanges; free access to professional culture; good distribution of benefit with a reduction in intra-state social and inter-state social. However, some 20 years after the generalization of the desktop computer, we can only observe the persistence of these apologetic speech despite the real impacts on society and its environment. We separate, for discursive reasons, the environmental and the social whose strong links we know in the real (Ramos-Soler et al. 2019; Saunila et al. 2019).

The desire to develop sustainable governance of the IS is consistent with real issues that are (Pearce et al. 2019):

- Support the user change through awareness, training and education, thinking about ways to consume less and do things differently;
- Optimize the ICT by developing technological and organisational innovation, as well as eco-design, and creating eco-labels covering hardware, software and services;
- Exploit largely the potential of the ICT to help other sectors to develop sustainably, to improve their processes and jobs, and to reduce their environmental footprint.

The sustainable governance allows several concepts to emerge, the most well-known is the Green IT.

Green IT is a holistic and systematic approach to addressing IT infrastructure issues such as the energy efficiency of data centers, the contribution of IT to the reduction in the environmental impacts of business activities (notably through the adoption of green technologies), the support of IT to eco-responsible business practices (such as contributing

to the implementation of a green value chain through carbon footprint monitoring and the development of energy options management tools) and the role of IT in the energy transition (via dematerialization). It is also the term used to refer to two conflicting conceptions of the relationship between IS and SD (the IS as a solution to SD and the IS as a problem to SD) (Asadi et al. 2018).

Sustainable governance allows the emergence of several concepts, the best known of which is Green IT. There are directives which consist of the direct contribution of data processing to the respect of the environment, and others consist of the indirect contribution (Schmermbeck et al. 2020).

2.1.1 For IT equipment

- The Convention "Bâle" adopted in 1989, which aims to control the movement of hazardous waste and reduce its quantity (Bohas et al. 2019).
- The Stockholm Convention concerns persistent organic pollutants (POPs) and aims to control and reduce or even ban certain polluting products (Leslie et al. 2016).
- The European WEEE directive (Waste electrical and electronic equipment) is aimed at the management and treatment of electrical or electronic waste. It is at the origin of the introduction of the ecotax or ecoparticipation paid by the consumer when purchasing his equipment (Messmann et al. 2019).
- The European RoHS directive (Restriction of the use of certain Hazardous Substances in electrical and electronic equipment) seeks to limit the use of dangerous substances in electrical or electronic equipment and oblige producers to reduce the use of six dangerous substances (the lead, mercury, cadmium …) (Powell-Turner et al. 2016).
- The European "Batteries" directive aims to increase the collection rate of batteries in Europe (Ylä-Mella and Román 2019).
- Energy Star is a global program to reduce the energy consumption of electronic equipment (Praprost et al. 2020).
- Green IT 1.0: It includes hardware, methods, software, services and IT processes that help reduce the impact of ICT and information systems on the environment. There is a desire to reduce the impact of IT on the environment throughout the life cycle of this hardware and software. That is to say, during their use (energy savings) but also during its design and up to the management of its waste and pollution (Deng et al. 2017).

  There are companies specializing in the recycling of obsolete computer equipment, which collect it from user companies, repackage it, and resell it to other interested organizations.
- Green IT 1.5: It corresponds to techniques aimed at reducing the impact of the organization of the company (support functions) on the environment. This scope includes both techniques aimed at reducing physical movement, through dematerialization and the exchange of computer data; and software to measure, simulate and reduce the organization's footprint: carbon accounting, software for rating suppliers' environmental performance, management tool and CSR reporting (corporate social responsibility). We are talking about the Sustainable Development Information System (SIDD) (Bakkas and El Manouar 2018).

2.1.2 For business processes

- Green IT 2.0: A continuous improvement approach which aims to reduce the economic, ecological and social footprint of a product or service by acting on information and communication technologies. Green IT 2.0 allows the reorganization of the entity to help, at each stage of the business process, to reduce the ecological footprint, indirectly (Deng et al. 2017).
- The ISO 14001 standard concerns environmental management in an organization. Compliance with the standard is a voluntary process (Sartor et al. 2019).
- The EMAS (Eco Management and Audit Scheme) regulation is an approach close to the ISO 14001 standard since it is aimed at organizations wishing to assess and/or improve their environmental performance. By simple declaration in accordance with EMAS criteria, any organization already ISO 14001 certified obtains the EMAS certificate. (Murmura et al. 2018)

The objective of our research work is how to develop a corporate culture oriented toward the IT environmental aspect, Green IT, while remaining aligned with strategic objectives. For this objective, we opted for an intelligent approach which considers all the good practices of green IT and the specifications of each company to design a global ecological benchmark adapted to the company in question.

2.2 Sustainable governance solutions and experimental results

2.2.1 Sustainable governance solutions

(a) *CIGREF SIER radar*

CIGREF SIER radar is a tool that can contribute to Sustainable Development, it proposed by CIGREF in 2010, and it is a self-assessment solution (Bohas et al. 2014).

The radar consists of 10 areas: frame of reference, IS eco-responsible governance, Green IT, Green IT usage and behavior, social and societal aspects, eco-responsible IT procurement, WEEE recycling, equipment and infrastructure, printing and consumables, projects and applications, and transportation (renamed "IT for green" in 2010 to expand its scope) (Bohas 2013).

Each of these areas is evaluated according to a score ranging from 1 to 4, the wording of which varies according to the areas concerned but whose meaning remains similar: 1 reflecting the lack of reaction on the part of the company, while 4 corresponds to a proactive approach.

Each area has an objective, for example, for the area "Governance", the objective is "Converging corporate SD and IS strategies".

(b) *DOTGREEN's greenargus online solution*

The greenargus addresses several themes: stakeholder culture, human resources, supplier relations, eco-design and recycling, energy savings and reducing CO_2 emissions.

This tool consists of eight survey dedicated to each of the themes addressed. The administration of the survey is done dynamically since the user's journey evolves according to his answers, allowing a personalized analysis (Bohas et al. 2014; Bohas 2013).

Based on the user's responses, a list of best practices and actions is proposed at the end of the evaluation.

(c) *CIGREF Green IT Dashboard*

In 2010, CIGREF proposed a set of indicators broken down into five areas forming the "Green IT Scoreboard". These axes are (Bohas 2013):

- Compliance and risk management.
- Human Relations.
- Relationships with suppliers.
- The Green IT "1.0"
- IT for Green

These axes are then broken down into sub-domains to which one or more indicators are attached. Some indicators are then refined among several other indicators. For example, the total amount of paper consumed can be broken down between the percentage of conventional white paper, the percentage of recycled paper and the percentage of recycled forest paper.

This tool thus perfectly complements the radar mentioned above by adding to the list of indicators proposed in the framework of good practice.

This dashboard can be used by the company to evaluate itself (although there is no standard provided to assess maturity) or as a basis for integrating an IT Green approach.

(d) *Datacenter Code of Conduct*

Although this tool differs from previous ones in that it is specific to the field of datacenters, it is nevertheless an interesting reference in terms of evaluation.

This tool, in the form of a dashboard developed in Excel, is structured around objectives, recommendations and indicators (Bohas 2013).

It provides a set of good practices against which the company can position itself according to whether it has already implemented them or intends to do so.

In fact, it involves the company in a process of continuous improvement since it can decide to gradually integrate these different practices according to its objectives.

The Code of Conduct thus includes some 100 recommendations. In terms of methodology, the person completes the scoreboard and then forwards it to the European body responsible for this program which will be in charge of analyzing the data provided by the company to assess whether it complies with this code (Bohas 2013).

2.2.2 Experimental results

"WeGreenIT" study launched by the Green IT Club with WWF France which aims to assess the digital environmental footprint and the maturity of large French companies in

the field of green IT, and to share expertise and good practices in this area within large French companies, which provides feedback for companies and their future.

The results presented allow companies to identify the sources of environmental impact of their information systems and offer them recommendations adapted to their sector of activity and their overall strategy.

After an analysis of the data collected, they noted a real interest from the 24 companies. Among the aspects analyzed is the maturity of companies regarding good "Green IT" practices. The following graph shows an average, based on 100, from the self-assessment of the 24 participating companies concerning their maturity in each major area (Fig. 1).

Most of the companies involved are aware of the environmental and social clauses to manage their activities well, but they do not always implement them. For example, in the "Workstation" area, companies have not yet implemented the most effective good practices to reduce the footprint of workstations such as "updating equipment rather than replacing it" or "favoring used equipment before considering new equipment". On the other hand, they systematize other good practices that are easier to implement and fairly effective. Hence, the choice of good practices is not effective.

2.2.3 Conclusion

We have thus seen that these different solutions have in common to be simultaneously evaluation tools but also guides for the action accompanying the organizations in the implementation of an ecological approach.

They are in fact similar in form since they are generally based on a dashboard architecture associated with graphical representations in the form of radars.

In terms of content, the study of these various solutions can highlight four essential elements (partially or totally present according to the tools):

- Questions and answers;
- Indicators, measures, ratios;

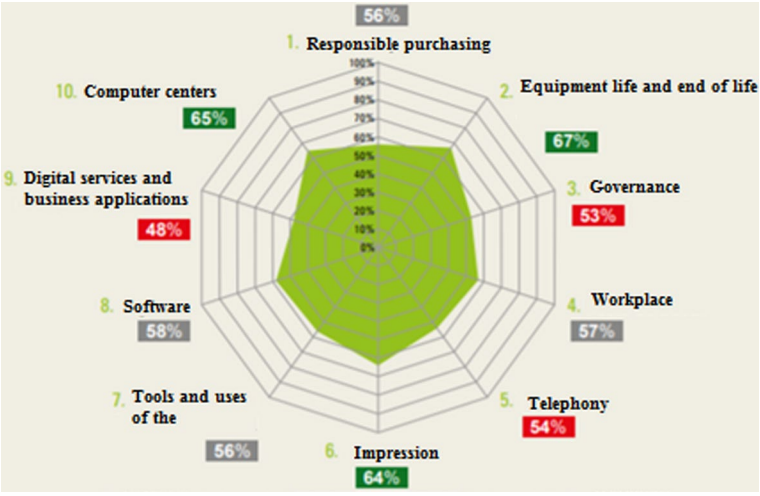

Fig. 1 Maturity of companies by domain

- Objectives;
- Recommendations as good practice.

These tools are intended to be used directly by users in the context of a self-assessment process, do not allow to accompany an enterprise in the realization of a complete mission of sustainable governance.

Also, according to the "WeGreenIT" study, we have conceived that the choice of ecological recommendations does not follow an optimal scenario.

The objective of our research is to design an ecological approach which consists in understanding the needs of companies and treating them by selecting the best recommendations.

A. 2.3. Artificial Intelligence for Sustainable Development

Artificial intelligence (AI) is a discipline that can be described in two ways, as a science that aims to discover the essence of intelligence and to develop intelligent machine; or as a science to find techniques for solving complex problems that cannot be solved without applying certain knowledge (for example, making good decisions based on large amounts of information) (Chakir et al. 2020). In the use of AI for sustainable development, we are gradually sticking to the second definition (Acemoglu and Restrepo 2018).

We need to reduce the complexity of solving a problem by dividing the necessary knowledge into subsets, and taking advantage of the powers of AI:

- Deduction, thinking, critical thinking (neural systems,…)
- Knowledge management
- Autonomy, Interaction, Learning, Reactivity, Proactivity, Situation
- Natural Language Processing
- Perception (acknowledgment, object acknowledgment, etc.)
- Social Intelligence

AI has been incorporated in various forms in the field of sustainability first through experimentation, then in sustainability programs. AI is invoked to influence global productivity, ecological outcomes and other different areas, both short and long term. AI affects positively all the SDGs. This is basically through technological breakthroughs forward that will prompt better results in a few parts. Figure 2 shows a schematic representation of the different interaction of AI and society (Vinuesa et al. 2020).

The environment collaborates with technology by giving the assets expected to technological advancement and is influenced by the environmental effect of technology. Furthermore, the environment is influenced either negatively or positively by the necessities, effects and selections of individuals and governments, which thusly require ecological assets. Likewise, environment is a basic layer that gives the "planetary limits" to the referenced interactions (Vinuesa et al. 2020).

The objective of our research is how to make the IT side of companies aligned with sustainable development in an intelligent way.

In the sustainable aspect, Green IT, new practices are emerging within the management of the information system which encourages the adoption of a responsible attitude by

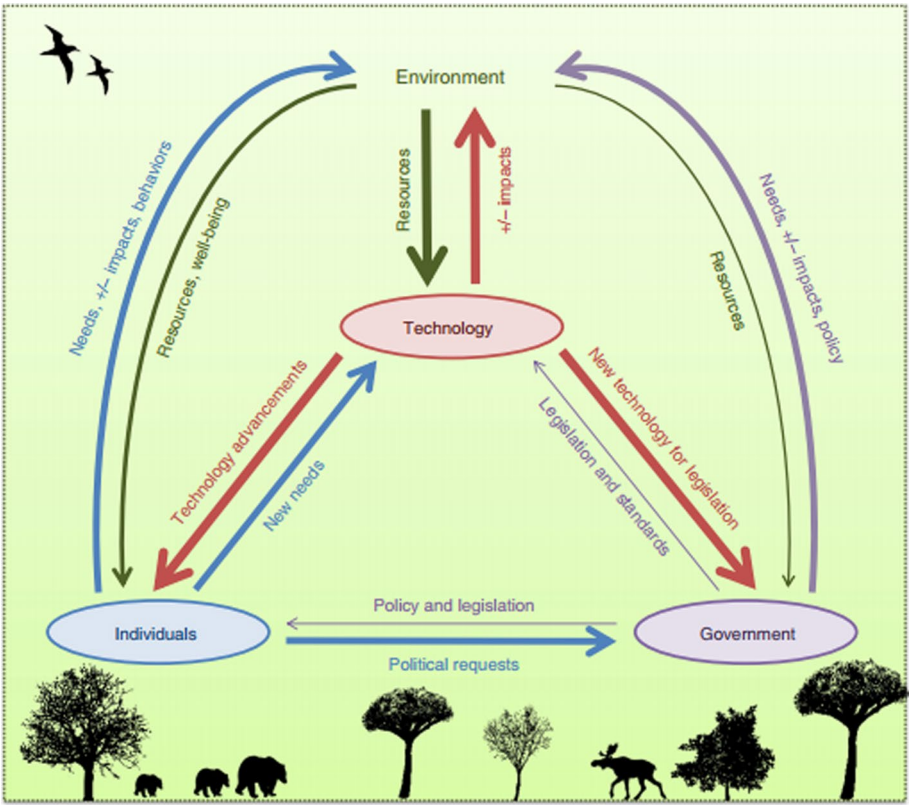

Fig. 2 Interaction of AI and society

taking into consideration the mode of operation, the mode of consumption, the relationship to the computer object. The problem is how to choose the best practice to be sustainable, hence the need to incorporate AI approaches to make the best decision about Green IT practices and recommendations.

3 Proposed approach

The continuous evolution of the ICT market requires frequent use of electrical equipment, which produces a consumption of non-renewable natural resources and a generation of pollution, e-waste, gas, etc.… The goal of our research is to balance ICT as a problem and ICT as a solution.

The proposed approach is to establish a framework based on AI that can propose an ecological strategy adapted to each organization taking into consideration the needs and the existing processes.

This approach evaluates the strengths and weaknesses of the company in terms of IT Green integration and measures the degree of sustainability of the IS. More specifically, it

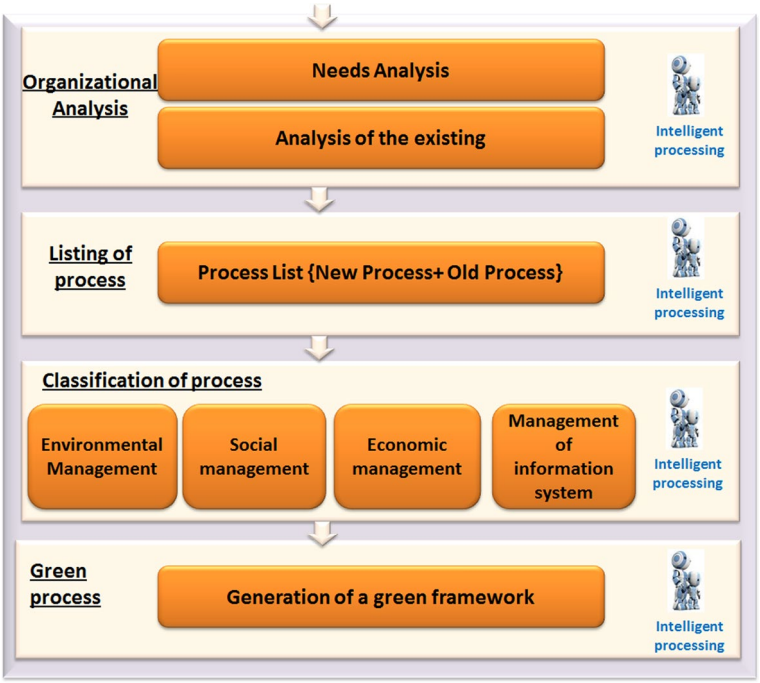

Fig. 3 The ecological approach

reports on the contribution of the IS (direct and indirect) to each dimension of sustainable development (SD): economic, environmental, societal and ethical.

This approach enables the creation of an ecological framework adapted to each organization by ensuring a permanent IT strategic alignment according to its constraints and needs. This ecological framework is designed and created in four layers. Each layer has an intelligent system (Fig. 3).

- ***Layer 1:Organizational Analysis***

The rule of this layer is the collecting in an intelligent interactive way the processes and the needs of the company to diagnose its maturity.

- ***Layer 2: Listing of process***

This layer organizes and unifies the existing processes and the needs of the enterprise in list of process by referring to a prototype process.

- ***Layer 3: Classification of process***

This layer allows the process to be classified according to the four ecological aspects; the three of them are pillars of sustainable development:

- Economic pillar: the economy is a pillar that occupies a preeminent place in each organization. Sustainable development involves changing production and consumption patterns by introducing measures to ensure that economic growth does not come at the expense of the environment and society (Hosseini and Kaneko 2012; Mbizvo et al. 2019).
- Social pillar: (or the human pillar) sustainable development encompasses the fight against social exclusion, widespread access to goods and services, working conditions, improved employee training and diversity, the development of fair and local trade (Hosseini and Kaneko 2012; Murphy 2012).
- Environmental pillar: it is the best known pillar, it help organization to preserve, to improve and to enhance the environment and natural resources over the long term by maintaining broad ecological balances, reducing risks and preventing environmental impacts (Hosseini and Kaneko 2012; Huttmanová and Valentiny 2019).
- Management of information system pillar: this aspect determines how organizations adopt technologies, systems and qualified practices of IT Green and it determines how to evaluate the practices of organizations as regards IT Green.

- ***Layer 4: Green process***

This layer creates a specific green framework adapted to each organization using AI, in three steps (Fig. 4).

In first step, this layer diagnostics the company's maturity in a smart way according to the four ecological aspects, by using a suite of performance indicators, further, it lists a set of ecological recommendations.

In second step, this system makes in an intelligent way the best recommendation, so this choice must ensure the strategic alignment and the ecological alignment of the company with ICT.

In third step; it implements the best recommendation, so if the choice is effective, the system integrates this recommendation in the green repository, if not it repeats the treatment to ensure the satisfaction of the chosen solution by using a set of indicators like eco-efficiency (If the evaluation indicator is greater than an evaluation threshold then the choice is ideal) (Fig. 5).

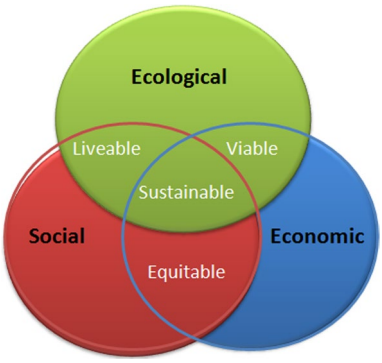

Fig. 4 The 3 pillars of sustainable development

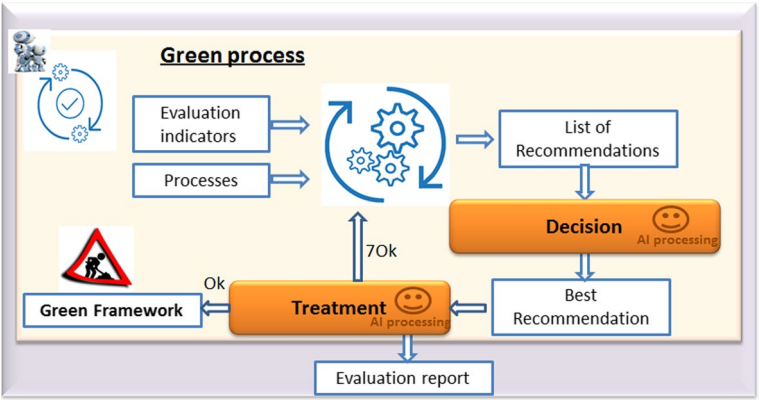

Fig. 5 Green process

4 Discussion

The daily use of information and communication technologies is considered to have a negative impact on the environment. Consequently, the Green ICT's mission is to reduce the negative effects of technologies on the environment. There are several concepts that have appeared, and which try to solve this problem but the most known and used is Green IT.

The problem arises how to balance between ICT 《as a problem》 and ICT 《as a solution》 .

In our research, we propose an ecological model based on the IT GREEN governance frameworks to select the best recommendations to reduce the impact of information systems on the environment, by taking in consideration the context of the organization and the IT strategic objectives expressed.

In addition, given the importance of interaction, coordination and collaboration with information systems, which are essential for the proper functioning of an organization, we integrate the concept of IA to our solution, which responds to these requirements.

The proposed solution provides a high-level ecological model that enables the implementation of the IT Green in an intelligent way according to four layers; each layer is implemented by a series of algorithms.

The following plan presents the algorithms of the green process to evaluate the company's maturity and to generate a specific ecological framework for this company (Fig. 6).

The following example presents the "Algorithm SelectRecommendation" that selects the list of the best recommendation to reduce the negative impact of the ICT.

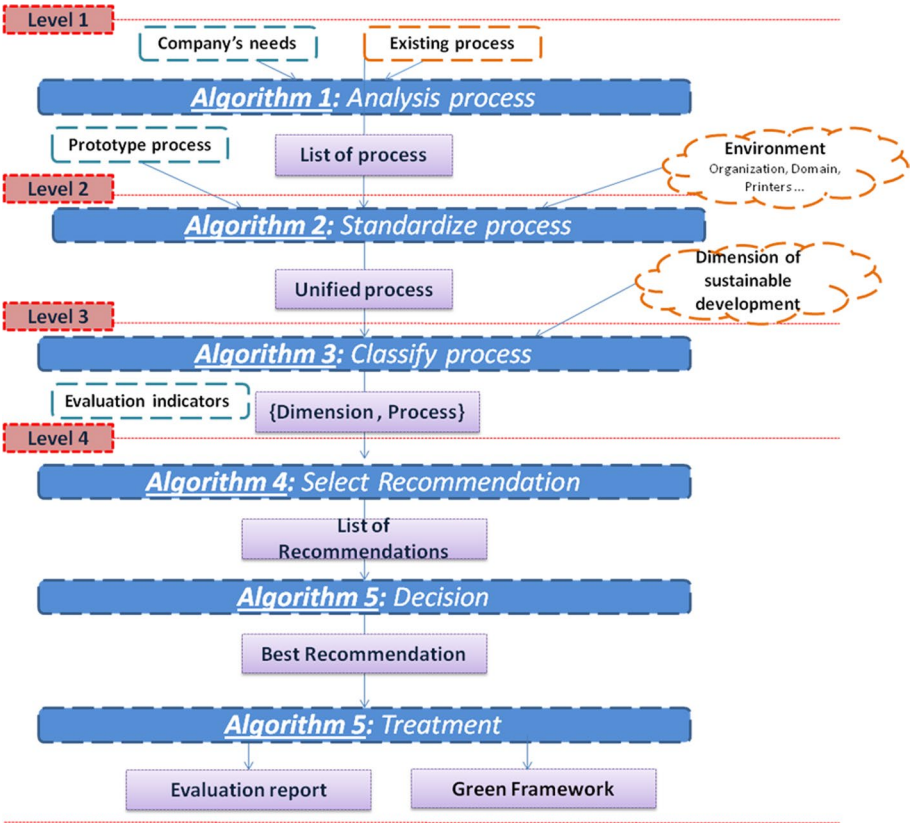

Fig. 6 Algorithms of the ecological approach

Algorithm **SelectRecommendation** ([Dimension, process], Evaluation_indicators)

For i from 1 to number of processes

IDRecommendation [j] = GetIDRecommendation (Dimension);

For j from 1 to size of IDRecommendation

k=0;

```
        If (Evaluation (process, Evaluation_indicators) is true)
        Begin
        IDSelectRecommendation [k] = IDRecommendation [j]
        ;
        k++;
        End If
    End For
    Return IDSelectRecommendation
    End
```

5 Conclusion

Our decision-making approach consists in designing an intelligent framework of IT ecological governance personalized and adapted to each company presented which makes it possible to assess the level of its maturity by taking into account its lost constraints, its new needs and ecological aspects and which allows to ensure the quality of the ICT alignment and which makes it possible to propose ecological recommendations based on all green IT standards in the form of action plans. Our approach makes it possible to meet the following criteria:

- Adaptability to any type of IS,
- Choose the best recommendation or the best recommendation without having prerequisites in the field of green IT.
- Intelligence and autonomy to understand business needs which are constantly changing,
- Distribution to involve stakeholders and heterogeneous components of the company,
- Scalability to accumulate the company's know-how in Green IT.

The proposed ecological approach considers the limitations of existing Green IT solutions, namely:

- Specialization in a particular business of the company,
- Rigid implementations of one of the green IT repositories.
- Need for prerequisites in the field of Green IT on the part of users to be able to use them.

As perspectives, firstly we program to do experimental tests to enrich our knowledge base and to have more evaluation indicators. Secondly, we plan to delve deeper into the translation of user's request for our approach to be interpretable by the IT Green community without having experts and auditors to perform this operation, so that our platform is generic.

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