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Green Information and Communication Technologies Implementation in Textile Industry Using Multicriteria Method

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Abstract

It has been recognized that green Information Communication Technology (ICT) is fast becoming popular in every sector. It's fundamental relevance to textile industry requires urgent attention than ever. Over the years selections of technologies to drive the textile industry has been a debate. There is a need for an efficient technology selection method to realize this goal. Selection of green ICT alternatives is a multicriteria decision making problem which has been sparsely explored in open literature. This study presents green ICT adoption in the textile industry using a fuzzy-TOPSIS multi-criteria approach for the most preferred ICT alternative in a textile industry. Criteria for Green ICT selection were identified by administering interview with selected textile and ICT industry experts at the managerial cadre of organizations and academics. Criteria considered were Implementation Cost (IC), Operating and Maintenance Cost (OMC), Environmental Impact (EI), Improved System Performance and Use (ISPU), Supply Chain Management (SCM) and Employment Opportunities (EO). Results shows that the most preferred ICT alternative is power management with overall coefficient of 0.60 while the least preferred is software optimization with coefficient of 0.23. This work will allow clean industrial process in the textile industry and also promote sustainable cities and communities through responsible consumption and production as highlighted by sustainable development goals (SDG) 11 and 12.

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1. Introduction

Now commercialized and computerized, the textile industry dates back to the early civilization of men when conventional techniques were adopted to establish the industry. The textile industry is one of the most important sectors of the economy. Although the various technological breakthroughs around the world has led to the globalization of the textile industry, the requirements for sustainability in the industry involves constant monitoring of the emerging trends in the market with respect to standards and regulations, raw materials, customer tastes and technical aspects of production [1]. In order to accomplish some of the targets under the 12th sustainable development goal, the textile industry is now more conscious of the issues of sustainability. As a result, the subject of sustainability in the textile and clothing industry is receiving special attention especially among the producers. Some of the strategies adopted are directed at securing the environment, protecting the people, adoption of renewable energy, energy efficiency and conservation, and environmentally friendly

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communication. As such, for sustainability purpose, the textile industry requires extensive and intensive application of various types of state-of-the- art enabling technologies. The adoption of information and communication technologies in the textile industry is one of the main technologies that can drive the required growth, development and expansion in the textile industry. The adoption of ICT in the textile industry would drive the changes required to enhance the sustainability of textile and clothing manufacturing and trade. Apart from making transactions and the production processes easier, the adoption of ICT in the textile industry would make response to emerging fashion trends prompt; ensure effectiveness and efficiency during design, processing and mass production; and expansion of market through the adoption of e-commerce that ensures ease of transactions and prompt feedback from customers [2]. To stay relevant and sustain growth in the competitive market, business organizations increasingly invest in way to improve services delivery. In this quest, the adoption of information and communication technologies is currently driving the dynamic of many markets to satisfy the increased thirsts of the consumers. Based on this, many business processes across almost all sectors depend on ICT for sustainability. Furthermore, with the mode by which data and information is being managed in the emerging markets and business, ICT has a great impact on sustenance of modern [3, 4, 5].

Green ICT/green computing deals with the aspect of computer resource relation process towards reducing power consumption. It concentrates on Central Processing Unit (CPU) efficiency, recycling and proper disposal of e-waste. The term "Green ICT" has been associated with manufacturing, usage, design and disposal of computer subsystems (Printers, Servers, hard disks, memory, monitors, network cards and so on) in a more efficient and effective manner with little or no negative impact on the environment [6].

To attain sustainability in the textile industry, the production and supply chain must be green as much as possible. These include the production, transportation, energy and most especially the communication departments of the industry. However, the adoption of green ICT technologies comes with various technical, costs and environmental implications that must be considered before they are implemented; hence, making the selection of the most appropriate green ICT in a textile industry is a multi-criteria problem. Based on aforementioned, this study presents a framework for the selection of the most appropriate green ICT adoption in the textile industry using a fuzzy-TOPSIS multi-criteria approach.

2. Literature

Karabasevic et al., discussed the influence of ICT in modern society due to increase societal demands [7]. The authors emphasized on the fact that; there is an aggressive search of new ideas and approaches to production especially in the textile industry. The business climate is more competitive, the market is dynamic, data exchange rate is high, systems integration is enormous and business support can barely survive without the technology support. They further emphasized on the need for green technology and its establishment in the textile industry. However, the work proposed bipolar fuzzy MILTIMOORA method. Today, professionals are fast considering Green IT both in academics and industry. Istrat and Lalić conducted a research with the objective to analyze various transactions in the textile industry [8]. Most of the transactions used were extracted using various database techniques to find the patterns of buyer's attitude towards improving decision-making. With this work, data mining techniques enhanced the decision-making process. Close to 2000 transactions records were used from the cloth making industry as a knowledge base. Interesting rules and various measures including customized offers were proposed in this work.

In [9] the possible use of automation tools in the manufacture of garment has been proposed. According to [10], supply selection is simply the process of identifying, contracting and evaluating suppliers through the purchaser. In another study [11]; various criteria for supplier evaluation and their importance were checked towards selecting and retaining competent suppliers. Some of the criteria identified in this are not based on specific organisation type or industry rather generalized. A separate research proposed multiple criteria decision analysis for supplier selection with focus on factors that can affect selection decision among others. [12]. To the best of our knowledge, the application of diverse green ICT alternatives in the textile industry is rare and emerging. In [13] various applications of decision-making methods in the textile industry were described. This paper presents a fantastic approach to select suitable Information Communication Technology approach (Green ICT) to enhance the supply chain activities in the textile industry. The advantages of green ICT such as Power management, Energy efficiency and conservation, Virtualization and Cloud computing, Materials recycling, Software Optimization, User Friendliness to mention few. This approach will provide more interesting result in the textile industry.

A subdivision of possible selection criteria in the textile industry under service, product, cost and supplier performances as been presented [14]. In [15], researchers gave a proposal on voting process as a method for making selection on textile related activities through one of the stages in the supply chain; the approach encouraged ranking as preferred over comparison for determining a potential supplier. Fuzzy AHP method was utilized by [16] for textile supplier's evaluation in India. From the same researcher, another review was carried out on various issues related to suitable supplier selections and their relationships with buyer. No doubt issues relating to supplier are dynamic. Organizations tend to invest in Green ICT to support decision making process for the best result in the business especially; to survive competition. An interesting study on general multicriteria decision making system and its implementation has been described in [13]. In addition, is an original approach that represents customers aspect in the fashion business, so this work addresses research in Green ICT specifically for Textile industry.

In [17] a theoretical model with dynamic application of technology related to skills and the impact of technology in textile industry was considered. This work is only from the skills perspective rather than holistic and no alternatives were proposed. However, the paper used common hypothesis in economics and embedded information systems to complement new skills required in the textile industry. It further reveals the room for continuous on-the-job training and higher level of education. In another research by [18, 19], various surveys on skilled and unskilled workers in textile industry was carried out to complement the work of [17]. The work demonstrates how new technologies can drive workers in the textile industry for better performances rather than sending deskilled workers out of job due to required technology skills.

The authors of [20] studied strategies related to textile industry from smart perspective through nanotechnology and electronic telecommunication. The study explored the high potential of smart materials in the field of textile. They used innovative technology applications different from the conventional textile approach to cover various market segments. Micro systems, material engineering and production technology were the focus of the work. This led to flexible economical fabrication, production compliance textile-based information system with more user applications. This work is relevant to next generation of fabrics and fibre coupled with items they produce. Albeit this work serves as a leverage for the work under study however, the current research work considers various experts in the field of technology especially the Green ICT which brings out more potential of unpopular application of technology to textile, therefore presents further implementation of scientific significance. From the literature review, it is important to note that enhancing the supply chain process in the textile industry is tightly coupled with criteria decision challenges, which green ICT can handle through various alternatives. [21, 22, 23, 24] carried out various analysis and algorithm on energy systems, distribution, performance analysis among other alternative power sources that could enhance going green and eventually saving costs of service production in textile industry. Hence this study presents a multi-criteria framework for the ranking of green ICT alternatives based on techno-economic and environmental criteria. Albeit the framework is developed for the Textile production industry; other industrial and production related sector can adopt and modify the framework proposed in this study for energy consumption reduction and going green.

3. Green Ict Alternatives in Textile Industy

This section discusses the various green ICT alternatives that could be considered for production, services and process enhancement in the textile industry. These include Power management, Virtualization, Cloud computing, Telecommuting, Software Optimization and User Friendliness. The considered alternatives are:

- Power Management (R1)
- Virtualization (R2)
- Cloud computing (R2)
- Telecommuting (R4)
- Software optimization (R5)
- User Friendliness (R6)

3.1. *Power Management*

One of the drivers of green computing is the reduction of power consumption while using latest technology as tools in business enhancement. This no doubt can help various automated systems deployed across high end computers, servers, workstations to mention are few in within textile industry operation [25]. The efficient handling of various power related systems and aspects of computer hardware through the use of Advanced Configuration and Power Interface (ACPI) to temporarily preserve power on terminals that are idle for long period is fast becoming important. ACPI is an advanced power management tool developed by Intel-Microsoft, it is useful for power consumption control facilitated by various technologies such as "SpeedStep" and "PowerNow" for under-volting depending on the workload adjustments [6]. Workers in the textile industry making use of computers need to be aware of power management tools available to minimize cost along economic factors in achieving sustainable development.

3.2. *Virtualization*

Virtualization as part of sustainability goals in green ICT reduces hardware requirements by ratio of 10:1 or even better [4]. Operational expenses are cut by 50% with resource virtualization on each server. Most textile industry can take advantage of this technology to cut cost of computing resources as part of the alternatives explored in this work. It is affordable, robust with high uptime. Virtualization results in far more efficient use of resources, including energy. One of the main purposes of virtualization is to make a single computer hardware function as if it is multiple places. Most of the computing resources that can be virtualized include but not limited to the hard disk, memory, network accessories among others. These components can be isolated into different parts and making them accessible by individual as a virtual infrastructure without necessarily making a new purchase for different purpose. Application of virtualization in textile can be replicated in the various supply chain activities in among sole distributors in the use of various Enterprise resource Planning solutions with heavy traffic and user requirements. This whole idea also helps in energy consumption reduction in data centers.

3.3. *User friendliness*

This is also another alternative; most ICT solution users look out for this a lot. While making choice of Software solutions, user instructiveness and friendliness is one of the vital factors that drives software acceptability even before testing by clients. This proposal as part of the green ICT alternatives in textile is very important. Textile industry is fashion driven with various styles colour combinations and attractiveness. So also, the solutions users expect a colour interface solution, easy to use, straight and direct while satisfying the business need. Graphical user interface and interoperability is also very important with this alternative. Various graphical packages involved in aforementioned, consume heavy resources including power hence need for green ICT consideration in fulfilling this aspect of textile industrial production processes.

3.4. Cloud computing

This is a scalable style of computing with multiple access information technology. It does not depend on immediate physical resource to function. With the idea of sustainable development (environment, economic and social). Cloud computing offers greater flexibility to various business model. Textile industry being a dynamic one; no doubt needs to update software solutions used in various stages of production. Most machines can now record production activities electronically, inventory is being managed using computer systems. With the proposal of cloud computing as an alternative; energy cost will be reduced and data in cloud are more secured with less worry about updates. Most of the maintenance activities are shifted to the cloud services providers. The solutions offered through cloud computing are pay as you use thereby eliminating unnecessary overhead associated with incorrect resource demand in organisation's planning [26].

3.5. Telecommuting

The importance of telecommunication-related technology in textile industry cannot be overemphasized. It ranges from phone calls, fleet management, email services, online meetings among others. Most devices used in the aforementioned are related to green ICT, with lesser power consumption and large memory support. Working from anywhere, rendering remote services especially with the advent of the pandemic is becoming more popular in every sector including textile. Customers and wholesalers can nowbook textile products remotely, organizations can have internal and external meetings through telecommuting resources hence a green ICT alternative that cannot be avoided. This technology has taken green ICT even to document management, e-auditing, electronic signatories and approvals. Thus, more space for teleworking with aggressive reduction of negative environmental impact. It enables video solutions and online collaborations in business environment like textile. [27].

3.6. Software optimization

Textile industry is associated with various software solution ranging from ERP, Customer Relationship Management (CRM) among other supply chain solutions. Optimizing these solutions for optimum performance to drive positive services delivery is very important. With this green ICT factor, no doubt; serious of unique and efficient initiatives will play a vital role in the textile industry. Software architectures are becoming smart through green ICT and this alternative will address series of conventional software architectural challenges in design, analysis, synthesis and evaluation.

4. Methods

To rank various alternatives based on conflicting criteria and metrics, decision makers have developed many robust multi-criteria-decision-making (MCDM) techniques [28]. Although these techniques typically most times produce same results, there are times when the techniques produces conflicting results [14, 29, 30]. MCDM methods allow experts to select the most preferred alternative from finite number of feasible alternatives. One of the most robust MCDM methods that has been extensively used by expert is the TOPSIS method; this is because of its rationality, simplicity, and comprehensibility. Also attributed to TOPSIS is its ability to quantify and estimate the relative performance of the alternatives in an easy mathematical expression and robust computational efficacy [13]. While it is acknowledged that TOPSIS generates quality output, professionals usually have preference for giving their opinions using linguistics terms; this usually makes evaluating uncertainties easier as compared to crisp value. Because of its robust nature, Fuzzy TOPSIS method was extended by Chen to capture uncertainty and the fuzzy nature of some multi-criteria decision problems [31]; and this has been deployed by researchers in various fields [11, 32, 33, 34, 35]. For this study, the efficacy of fuzzy-TOPSIS is deployed to evaluate and rank the most relevant green ICT strategy applicable to a textile factory. The ranks of the alternatives are based on the relative closeness index from the fuzzy negative ideal solution (FNIS) and fuzzy positive ideal solution (FPIS). The steps followed in the implementation of the Fuzzy-TOPSIS include:

Step 1: Develop a decision matrix
In this step, the literature is explored to identify relevant green ICT alternatives and the relevant criteria. These alternatives were rated by 5 experts using a ten-point fuzzy scale. The data was collected with the aid of a well-designed questionnaire.

Step 2: Develop the normalized decision matrix using the following expression which is based on negative and positive ideal solutions:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad \text{and } c_j^* = \max_i \left\{c_{ij}\right\} \text{ (beneficial)} \quad (1)$$

or

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \quad \text{and } a_j^- = \min_i \left\{a_{ij}\right\} \text{ (non} - \text{beneficial)} \quad (2)$$

Step 3: Develop the weighted normalized decision matrix using the following expression:

$$\tilde{V} = \left(\tilde{v}_{ij}\right);\ \tilde{v}_{ij} = \tilde{r}_{ij} \times w_j \quad (3)$$

Step 4: Calculate the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) using the mathematical expression:

$$\text{FPIS}(A^*) = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots \tilde{v}_n^*), \quad \text{where } \tilde{v}_j^* = \max_i \left\{v_{ij3}\right\}; \quad (4)$$

$$\text{FNIS}(A^-) = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_n^-), \quad \text{where } \tilde{v}_j^- = \max_i \left\{v_{ij1}\right\}; \quad (5)$$

Step 5: Compute the distance between each alternative and FPIS and FNIS using the expression:

$$d_i^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \quad (6a)$$

$$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right). \quad (6b)$$

But

$$d(\tilde{x}, \tilde{y}) := \sqrt{\frac{1}{3}\left[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2\right]}. \quad (7)$$

Step 6: Evaluate the closeness coefficient and rank the alternatives

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*} \quad (8)$$

4.1. Illustrative example

Green computing and technology have gained popularity in recent times however, in future services arms of Original Equipment Manufacturers (OEMs) will consider incorporating green ICT into their service offerings with good focus on optimization, integration and customer centric offers. Telecommunication service providers will also play more role in the future of green ICT through recycling programs and sustainable innovations [28, 36, 37]. Recently, some government agencies took radical actions resurrect textile industry so as to regulate their importation especially in western Africa. One of the major issues that lead to importation is the economic recession that affected many nations in past few years. Considering all forms of textile materials being blessed by some African countries as a case study, the adoption of green ICT in the journey will provide better results considering the various criteria identified in this work [38]. The textile industry in Taiwan also faced with some challenges such as low labour and manufacturing cost. This work will create increased awareness on how green ICT alternative/multicriteria framework will encourage competition, reduce environmental hazards in the midst of harsh economy and global recession.

In [38] an illustrative overview of a typical Textile industry was provided. The challenges and possible solution reveal from this work is leveraged upon to support the green ICT perspectives and impact in the textile industry. The authors mentioned a textile industry in western Africa as the largest employer of labour, and a major player in the manufacturing sector of the economy in the past. Unfortunately, it has seized to be a major contributor to the foreign exchange due to inadequate power supply, inconsistent government policies smuggling of foreign materials among others. A critical assessment of this cases study and its challenges proposed solutions along political will for sustainable development. The solution can be best implemented using the green ICT, green ICT drives policy, the use of modern software solutions for tracking of importation, automation of supply chain activities with technology that consume less power will elevate and resuscitate the sector.

Most western African countries used to be the most thriving textiles industry in Africa. The discovering of other economic resources such as oil no doubt impacted its sustainability among other challenges [39]. With the advent of green ICT, most of these challenges can be solved and application of technology to this industry can possibly make it another oil for most nations whom have suffered similar setback in the textile industry. The future is green, and green ICT is here to stay. The rapid increase of technology development also reveals huge opportunities power management, decreasing pollution effects in the environment as identified in Table 1.

5. Results

To establish the viability of the proposed framework, the proposed model is adapted to a textile industry. Six green ICT alternatives that will enhance the textile industry operations were evaluated based on six criteria. The green ICT alternatives considered in this regard include Power Management (R_1), Virtualization (R_2), Cloud computing (R_3), Telecommuting (R_4), Software optimization (R_5), User Friendliness (R_6). For ease, the alternatives are denoted by the set $Q = R_1, R_2, R_3, R_4, R_5, R_6$, respectively. Using the six criteria $C = W_1, W_2, W_3, W_4, W_5, W_6$ described in Table 1, the alternatives were ranked in order of preference.

In this illustrative example, a total of five experts (g ∈ G) from the industry and the academics with a sound knowledge on the issue of various textile production and value chain related to computing and ICT were contacted for their knowledge and expertise on the subject. Some of the experts have a Doctorate degree while the minimum educational qualification of the experts is Masters in the field of textile, processing, production, supply changing management and ICT with not less than 10 to 20 years of experience respectively. They all acknowledged that they are aware of the numerous impact green ICT could make in the textile industry. They also agreed that various criteria should be considered in selecting green ICT technologies with respect to textile industry. Table 2 presents the details of some of the questions and their responses.

The opinions of the experts were collected with the aid of a well-structured questionnaire that points toward the importance of the criteria and the relationship between the alternatives and the criteria that was selected. The experts were assigned equal weights during the analysis of their responses. The linguistic responses obtained from the experts are presented in Table 3 based on the triangular fuzzy number [1, 2, 26, 40]. The fuzzy

Table 1: Criteria considered in the study

Factor	Criteria	Description	Remark
Environmental	Environmental Impact (W_1)	Use of ICT to drive policies that reduces negative impact on environment and general human living conditions.	Beneficial
	Operating and Maintenance (W_2)	Smooth and continuous operation, services and textile equipment.	Non-beneficial
Economic	Implementation Cost (W_3)	Cost of deployment and implementation of Green ICT tools in line with global practices and standards.	Non-beneficial
	Improved System Performance and Use (W_4)	Improvement of services and general performance ranging from training of staff, acquisition of additional knowledge and skills in the area of Green ICT	Beneficial
Technical	Supply Chain Management (W_5)	Simple, friendly, and interactive ICT Solutions that are usable by citizen of different categories and specializations towards climate change adaptation.	Beneficial
	Employment(W_6) Opportunities	ICT Solutions that are flexible with easy upgrade features in case of change. Modifiable technical components as climate change evolves	Beneficial

Table 2: Excerpt of Expert Response

Questions	g_1	g_2	g_3	g_4	g_5
Have you heard of "green ICT"?	Yes	Yes	Yes	Yes	Yes
Do you feel the green ICT can impact textile industry positively?	Yes	Yes	Yes	Yes	Yes
If yes, do you agree that different criteria should be considered in selecting green ICT technologies with respect to Textile industry processes?	Yes	Yes	Yes	Yes	Yes
Highest Qualification	Ph.D.	M.Sc.	M.Sc.	Ph.D.	Ph.D.
Years of Experience	16-20	16-20	16-20	11-15	16-20
Organisation	Academics	Industry	Industry	Academics	Industry

decision matrix of each expert's opinions are combined using the elementary operators of the fuzzy triangular numbers such that the overall judgments and preference rating are extracted for the various green ICT alternatives (Table 4). The same procedure is followed to obtain the weights of the criteria from the preferences provided by the experts before conversion to crisp values. The aggregate results of the weights of the criteria are presented in Table 5. The weighted normalized decision matrix and the Fuzzy PIS and fuzzy NIS are given in Tables 6 and 7, respectively.

6. Discussion

The closeness coefficient of the various green ICT alternatives is obtained as 0.60, 0.43, 0.47, 0.45, 0.23 and 0.27 for R1, R2, R3, R4, R5 and R6, respectively (Figure 1). The result shows that power management is the most effective green ICT alternative for the textile industry. This is not far-fetched from the fact that textile industry is greeted with large and industrial machineries which are now being integrated with Information technology tools through data centers, server management and end to end technology driven processes that are used in the production and manufacturing processes hence power plays a vital

Table 3: Alternative rating using linguistic terms

g_1						
	W_1	W_2	W_3	W_4	W_5	W_6
R_1	H	EH	VVH	VH	A	AA
R_2	A	EH	EH	EH	H	BA
R_3	VH	VH	VH	VVH	AA	AA
R_4	AA	EH	VVH	VVH	VH	VVH
R_5	A	VH	EH	EH	VH	H
R_6	L	VVH	A	VVH	VVH	VH

g_2						
W_1	W_2	W_3	W_4	W_5	W_6	
R1	VL	L	AA	VH	L	VH
R2	VL	L	A	EH	BA	A
R3	VL	L	A	AA	H	A
R4	VL	L	A	VVH	A	A
R5	VL	EH	A	EH	VH	VH
R6	VL	EH	A	VVH	VVH	A

g_3						
	W_1	W_2	W_3	W_4	W_5	W_6
R_1	VL	L	A	VH	L	H
R_2	L	L	L	H	L	H
R_3	VL	VL	A	VH	L	H
R_4	VL	L	A	VH	L	H
R_5	VL	A	A	VH	VL	H
R_6	VL	L	A	H	H	H

g_4						
W_1	W_2	W_3	W_4	W_5	W_6	
R1	VL	L	A	VH	L	H
R2	L	L	L	H	L	H
R3	VL	VL	A	VH	L	H
R4	VL	L	A	VH	L	H
R5	VL	A	A	VH	VL	H
R6	VL	L	A	H	H	H

g_5						
	W_1	W_2	W_3	W_4	W_5	W_6
R_1	A	H	EH	A	AA	H
R_2	A	AA	VH	A	AA	L
R_3	A	AA	H	A	EH	L
R_4	AA	A	H	A	EH	L
R_5	AA	A	A	A	VH	L
R_6	L	L	A	A	H	L

Table 4: Combined responses of the experts

	W_1	W_2	W_3	W_4	W_5	W_6
R1	(1,3.6,8)	(1,4.8,10)	(1,5.2,10)	(47.4,9)	(1,3.6,7)	(5,7,9)
R2	(1,3.6,6)	(1,4.6,10)	(2,5.8,10)	(4,7.8,10)	(2,4.6,8)	(2,5.2,8)
R3	(1,3.8,9)	(1,3.8,9)	(4,6,9)	(4,6.6,9)	(2,5.8,10)	(2,5.4,8)
R4	(1,3.6,7)	(1,4.4,10)	(4,6.2,10)	(4,7.8,10)	(2,5.8,10)	(2,6.2,10)
R5	(1,3.4,7)	(4,6.6,10)	(4,6,10)	(4,8.2,10)	(1,5.6,9)	(2,6.4,9)
R6	(1,2.4,4)	(2,5.6,10)	(4,5,6)	(47.4,10)	(6,7.8,10)	(2,6,9)

Table 5: Consolidated weight allocated to criteria

Criteria	Weight of the selection index					Combined weight
	g_1	g_2	g_3	g_4	g_5	
W_1	EMI	VMI	EMI	VVMI	MI	(6,8.8,10))
W_2	EMI	I	VVMI	EMI	VVMI	(5, 8.8, 10)
W_3	VVMI	I	I	MI	VVMI	(5, 7.4, 10)
W_4	VVMI	VMI	VMI	I	VMI	(5, 8, 10)
W_5	EMI	I	I	I	VVMI	(5, 7.4, 10)
W_6	MI	MI	I	I	MI	(7, 6.6, 8)

role and results shows, it is the most preferred alternative, followed by cloud computing, telecommuting and virtualization respectively; these closeness in the results shows how tightly coupled the technology drivers of the production output in textile industry are. Most processes are now reachable by very wide audience due to popular and increased rate of cloud service migration; down the line are some previous on - premise technologies as shown in the result (telecommuting and virtualization). User friendliness and software optimization are the least preferred alternatives based on the output of this research; although also important but compared to other options the effect of these criteria in line with the textile industries operations and service delivery could be taken care of at a relatively moderate level in the supply chain process without creating much negative impact in the entire service delivery. Overall, the most preferred green ICT alternative is making a choice of green ICT

Table 6: Weighted normalized decision matrix

	W_1	W_2	W_3	W_4	W_5	W_6
R_1	(0.7,3.5,8.9)	(0.5,1.8,10,0)	(0.5,1.4,10.0)	(2.0,5.9,9.0)	(0.5,2.7,7.0)	(2.5,3.5,7.2)
R_2	(0.7,3.5,6.7)	(0.5, 1.9, 10.0)	(0.5,1.3,5.0)	(2.0,6.2,10.0)	(1.0,3.4,8.0)	(1.0,2.6,6.4)
R_3	(0.7,3.7,10.0)	(0.5, 2.3,10)	(0.5,1.2,2.5)	(2.0,5.3,9.0)	(1.0,4.3,10)	(1.0,2.7,6.4)
R_4	(0.7,3.5,7.8)	(0.5,2.0,10.0)	(0.5,1.2,2.5)	(2.0,6.2,10.0)	(1.0,4.3,10.0)	(1.0,3.1,8.0)
R_5	(0.7,3.3,7.8)	(0.5,1.3,2.5)	(0.5,1.2,2.5)	(2.0,6.6,10.0)	(0.5,4.1,9.0)	(1.0,3.2,7.2)
R_6	(0.7,2.3,4.4)	(0.5,1.6,5.0)	(0.8,1.5,2.5)	(2.0,5.9,10.0)	(3.0,5.8,10)	(1.0,3.0,7.2)
A*	(0.7,3.7,10.0)	(0.5, 2.3,10.0)	(0.8,1.5,10.0)	(2.0,6.6,10.0)	(3.0,5.8,10)	(2.5,3.5,8.0)
A-	(0.7,2.3,4.4)	(0.5,1.3,2.5)	(0.5,1.2,2.5)	(2.0,5.3,9.0)	(0.5,2.7,7.0)	(1.0,2.6,6.4)

Table 7: Fuzzy PIS and fuzzy NIS

Distance from FPIS							
	W_1	W_2	W_3	W_4	W_5	W_6	di*
R_1	0.7	0.3	0.2	0.7	2.9	3.9	8.56
R_2	1.9	0.2	2.9	0.2	2.1	4.4	11.75
R_3	0	0	4.3	0.9	1.4	4.4	11.09
R_4	1.3	0.2	4.3	0.2	1.4	4.8	12.25
R_5	1.3	4.4	4.3	0	1.8	4.6	16.41
R_6	3.3	2.9	4.3	0.4	0	4.6	15.5

Distance from FNIS							
R_1	W_1	W_2	W_3	W_4	W_5	W 6	di-
R_2	2.7	4.3	4.3	0.4	0	1.1	24.76
R_3	1.5	4.3	1.4	0.8	0.8	0	33.08
R_4	3.3	4.4	0	0	2	0.1	33.26
R_5	2	4.3	0	0.8	2	1	35.27
R_6	2	0	0	0.9	1.4	0.6	43.57
R_7	0	1.4	0.3	0.7	2.9	0.5	40.28

related services that makes provision for effective power management in achieving set goals and objectives.

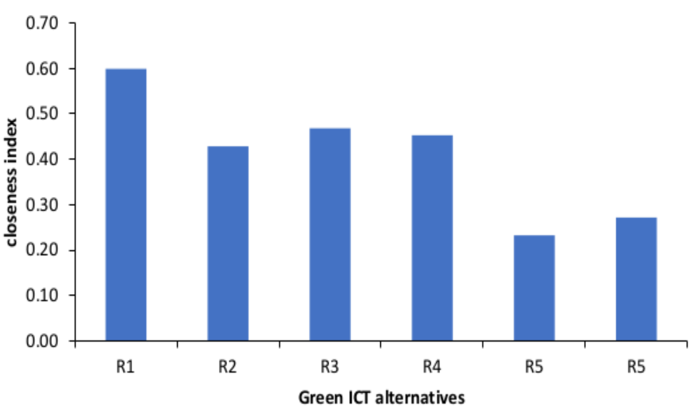

Figure 1: Closeness Coefficient

7. Conclusion

The application of green ICT using a multicriteria decision making method is a highly important task especially in textile industry. The great potential positive impact in the textile industry will not only boost performance in the entire supply chain trend but also create diverse opportunities to tackle various challenges at different stages resulting to improved customer satisfaction. This research provided a method for selecting the best technology that will enhance textile industry activities using green ICT with the use of real case study as an example. Three major novel contribution has been achieved with this research namely, application of green ICT to textile industry, confident selection of the best technology that will encourage transparent and profit-oriented service delivery, incorporation of customers perspectives into service delivery through the use of ICT techniques and lastly, this research is capable of being a decision-making reference tool in the selection of IT tools especially for startups in the textile industry. The outcome of this study is expected to save cost, reduce energy consumption as well as emission in the society. Furthermore, climate change, environmental and health impact will be drastically reduced. It is anticipated that decision makers will adopt and implement the proposed framework in developing a green textile production. Although the advantage of the Fuzzy Topsis approach are numerous which include simplicity, rationality, comprehensibility, good computational efficiency and ability to measure the relative performance for each alternative in a simple mathematical form. The limitation of this method include high labor input, large amount of initial data, and limited nature of the assessment scale. Future study will adopt/develop robust multi criteria methods to test the efficacy of the proposed framework and possibly use other MCDM methods to benchmark the present fuzzy-TOPSIS approach developed as well as comparison of the result obtained from the study.

References

[1] G. Kokeza and S. Urošević, "Strategic directions of the development of the textile and clothing industry in the Republic of Serbia", Tekst. Ind. **66** (2018) 69.

[2] S. Lu, P. Y. Mok, and X. Jin, "A new design concept: 3D to 2D textile pattern design for garments", Comput. Des. **89** (2017) 35.

[3] J. Ding, Z. Song, and W. Liu, "An empirical study on the spatial organization variation with the application of Information and Communication Technologies (lCTs): a case study of textile and apparel enterprises in China", Geogr. Res. **28** (2009) 883.

[4] R. B. A. Mouelhi, "Impact of the adoption of information and communication technologies on firm efficiency in the Tunisian manufacturing sector", Econ. Model. **26** (2009) 961.

[5] S. Luthra, S. K. Mangla, F. T. S. Chan, and V. G. Venkatesh, "Evaluating the drivers to information and communication technology for effective sustainability initiatives in supply chains", Int. J. Inf. Technol. & Decis. Mak. **17** (2008) 311.

[6] K. S. Dar, S. Asif, and A. Islam, "Power Management and Green Computing: An Operating System Prospective", Can. Int. J. Soc. Sci. Educ. (2015) 165.

[7] D. Karabasevic, P. Radanov, D. Stanujkic, G. Popovic, and B. Predic, "Going green: strategic evaluation of green ICT adoption in the textile industry by using bipolar fuzzy MULTIMOORA method", Ind. Textila **72** (2021) 3.

[8] V. Istrat and N. Lalić, "Association rules as a decision making model in the textile industry", Fibres & Text. East. Eur., 2017.

[9] A. Baccini and M. Cioni, "Is technological change really skill-biased? Evidence from the introduction of ICT on the Italian textile industry (1980–2000)", New Technol. Work Employ. **25** (2010) 80 .

[10] M. Tavana, A. Shaabani, S. Mansouri Mohammadabadi, and N. Varzgani, "An integrated fuzzy AHP-fuzzy MULTIMOORA model for supply chain risk-benefit assessment and supplier selection", Int. J. Syst. Sci. Oper. & Logist. **8** (2021) 238.

[11] F. R. L. Junior, L. Osiro, and L. C. R. Carpinetti, "A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection", Appl. Soft Comput. **21** (2014) 194.

[12] S. A. Burney and S. M. Ali, "Fuzzy multi-criteria based decision support system for supplier selection in textile industry", IJCSNS **19** (2019) 239.

[13] E. Roszkowska, "Multi-criteria decision making models by applying the TOPSIS method to crisp and interval data", Mult. Criteria Decis. Making/University Econ. Katowice **6** (2011) 200.

[14] G. Kou, Y. Lu, Y. Peng, and Y. Shi, "Evaluation of classification algorithms using MCDM and rank correlation", Int. J. Inf. Technol. & Decis. Mak. **11** (2012) 197.

[15] R. S. Q. Lai, L.-L. Hsu, and J. C. H. Chen, "Green supply chain management systems: A case study in the textile industry", Hum. Syst. Manag. **31** (2012) 111.

[16] D. Karabasevic, G. Popovic, D. Stanujkic, M. Maksimovic, and C. Sava, "An approach for hotel type selection based on the single-valued intuitionistic fuzzy numbers", Int. Rev **1** (2019) 7.

[17] P. Funk and T. Vogel, "Endogenous skill bias", J. Econ. Dyn. Control **28** (2004) 2155.

[18] M. Sanders and B. Ter Weel, "Skill-biased technical change: theoretical concepts, empirical problems and a survey of the evidence", 2000.

[19] D. Acemoglu, "Cross-country inequality trends", Econ. J. **113** (2003) F121.

[20] L. Affatato and C. Carfagna, "Smart Textiles: a strategic perspective of textile industry", in Advances in Science and Technology **80** (2013) 1.

[21] G. R. Venkatakrishnan, R. Rengaraj, K. K. Sathish, R. K. Dinesh, and T. Nishanth, "Implementation of Modified Differential Evolution Algorithm for Hybrid Renewable Energy System", J. Niger. Soc. Phys. Sci. **3** (2021) 209.

[22] A. S. Maihulla and I. Yusuf, "Performance Analysis of Photovoltaic Systems Using (RAMD) Analysis", J. Niger. Soc. Phys. Sci. **3** (2021) 172.

[23] B. M. Dyavappa, "Energy distribution of an ion cloud in a quadrupole Penning Trap", J. Niger. Soc. Phys. Sci. **2** (2020) 55.

[24] S. S. Mohammed, "On fuzzy soft set-valued maps with application", J. Niger. Soc. Phys. Sci. **2** (2020) 26.

[25] A. B. Naeini, A. Mosayebi, and N. Mohajerani, "A hybrid model of competitive advantage based on Bourdieu capital theory and competitive intelligence using fuzzy Delphi and ism-gray Dematel (study of Iranian food industry)", Int. Rev. **1** (2019) 21.

[26] C. Zhang, C. Chen, D. Streimikiene, and T. Balezentis, "Intuitionistic fuzzy MULTIMOORA approach for multi-criteria assessment of the energy storage technologies", Appl. Soft Comput. **79** (2019) 410.

[27] P. Pazowski, "Green computing: latest practices and technologies for ICT sustainability", in Managing Intellectual Capital and Innovation for Sustainable and Inclusive Society, Joint International Conference, Bari, Italy (2015) 1853.

[28] D. Stanujkic, E. K. Zavadskas, D. Karabasevic, F. Smarandache, and Z. Turskis, The use of the pivot pairwise relative criteria importance assessment method for determining the weights of criteria. Infinite Study (2017).

[29] G. Kou, Y. Peng, and G. Wang, "Evaluation of clustering algorithms for financial risk analysis using MCDM methods", Inf. Sci. (Ny). **275** (2014) 1.

[30] E. Kuruoglu, D. Guldal, V. Mevsim, and T. Gunvar, "Which family physician should I choose? The analytic hierarchy process approach for ranking of criteria in the selection of a family physician", BMC Med. Inform. Decis. Mak. **15** (2015) 1.

[31] C.-T. Chen, "Extensions of the TOPSIS for group decision-making under fuzzy environment", Fuzzy sets Syst. **114** (2000) 1.

[32] D. Yong, "Plant location selection based on fuzzy TOPSIS", Int. J. Adv. Manuf. Technol. **28** (2006) 839.

[33] T.-C. Chu and Y.-C. Lin, "A fuzzy TOPSIS method for robot selection", Int. J. Adv. Manuf. Technol. **21** (2003) 284.

[34] Y. A. Solangi, C. Longsheng, and S. A. A. Shah, "Assessing and overcoming the renewable energy barriers for sustainable development in Pakistan: An integrated AHP and fuzzy TOPSIS approach", Renew. Energy **173** (2021) 209.

[35] P. K. Roy and K. Shaw, "Developing a multi-criteria sustainable credit score system using fuzzy BWM and fuzzy TOPSIS", Environ. Dev. Sustain. (2021) 1.

[36] N. A. Nabeeh, A. Abdel-Monem, and A. Abdelmouty, A hybrid approach of neutrosophic with multimoora in application of personnel selection. Infinite Study, (2019).

[37] R. Mai, Y. Liu, Y. Li, P. Yue, G. Cao, and Z. He, "An Active-Rectifier-Based Maximum Efficiency Tracking Method Using an Additional Measurement Coil for Wireless Power Transfer", IEEE Trans. Power Electron. (2018), doi: 10.1109/TPEL.2017.2665040.

[38] C. O. O. and E. O. O. Owena, "THE NIGERIAN TEXTILE INDUSTRY: AN OVERVIEW.", Niger. J. Polym. Sci. Technol. **11** (2016) 99.

[39] S. Onyeiwu, "The modern textile industry in Nigeria: history, structural change, and recent developments", Text. Hist. **28** (1997) 234.

[40] C.-Y. Chen, C.-Y. Liu, C.-C. Kuo, and C.-F. Yang, "Web-based remote control of a building's electrical power, green power generation and environmental system using a distributive microcontroller", Micromachines **8** (2017) 241.