Green Energy and Technology

Tomayess Issa
Theodora Issa
Touma B. Issa
Pedro Isaias *Editors*

Sustainability Awareness and Green Information Technologies

Springer

Green Energy and Technology

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Tomayess Issa · Theodora Issa ·
Touma B. Issa · Pedro Isaias
Editors

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Editors
Tomayess Issa
Curtin University School
of Information Systems
Perth, WA, Australia

Theodora Issa
Curtin University CBS—School
of Management
Bentley, WA, Australia

Touma B. Issa
Murdoch University
Perth, WA, Australia

Pedro Isaias
School of Information Systems
and Technology Management
University of New South Wales
Kensington, NSW, Australia

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Foreword

In light of the global rivalry amongst countries to gain a competitive advantage in international markets, and be able to stand strong in the international business arena in all sectors, the notion of sustainability has become a basis for empowering countries economically, politically, socially, technologically and demographically. Sustainability in its broad sense can be framed as a comprehensive activity that is conducted by both public and private sectors or even among individuals, which aims to improve the living conditions of all people without increasing the use of natural resources beyond the planet's endurance. Hence, awareness of sustainability has expanded and become a global cultural consensus for all categories of the society.

In terms of technology, efforts are consolidated to find methods to produce technology in ways that do not harm or deplete the Earth's natural resources. Consequently, the concept of green IT was coined, and policies and procedures are created to ensure that the best technological manufacturing and production practices are followed to protect environment and contribute to reducing carbon emissions and global warming. These efforts also include developing and raising the efficiency of the ICT infrastructure through the use of energy-efficient equipment and the development of modern low-energy technologies. Academic researchers are also committed to contribute to these endeavours through establishing research and development programs in the field of green IT applications, and increasing awareness amongst all segments of the IT community to the importance of rationalizing energy consumption as well as implementing projects for reuse of e-waste.

The idea of this edited book has been brought by the editors to contribute to these ongoing exertions by establishing the theoretical background with reviewing the literature on state-of-the-art technologies and developments related to sustainability awareness and green IT. The editors have succeeded in bringing together an interesting and inspiring set of research contributions reporting on the progress of sustainability awareness and green IT within numerous domains. Divided into four parts, i.e. "What is Sustainability?" "Sustainability Awareness and Importance among individuals and organizations in developed and developing countries," "Green IT Strategies and Models" and "Green IT Technologies," this edited book presents an adequate assortment of papers emphasizing the significance of this important topic not only from the viewpoint of dissimilar theoretical scientific fields involved, but also from an application point of view. To the best of my knowledge, this is the first book that presents a valuable window on sustainability awareness and green IT research and covers the necessary components covering the full spectrum of relevant applications, ranging from theoretical reviews all the way to many dissimilar technical applications including Virtualization, Cloud Computing, Social Networking and Smart Technology, to name a few. These venues make the edited book exceptional and an important source of information for students, lecturers and also industry professionals who are involved in areas of sustainability awareness and green IT technologies.

The challenges in sustainability awareness and green IT are both difficult and interesting. People are working on them with enthusiasm and dedication to develop new solutions to keep up with the ever-changing environmental threats that compromise the future generations. In this era of globalization, it is necessary to provide IT practitioners, both professionals and students, with state-of-the-art knowledge on the frontiers in sustainability awareness and green IT. This edited book is a good step in that direction. Congratulations to all those who have contributed!

Bilal Abu-Salih
Assistant Professor
King Abdullah II School of Information Technology
The University of Jordan, Jordan

Preface

Everything came to be by his hand; and without him not even one thing that was created came to be. (John 1:3)

ܟܠ ܒܐܝܕܗ ܗܘܐ ܘܒܠܥܕܘܗܝ
ܐܦܠܐ ܚܕܐ ܗܘܬ ܡܕܡ ܕܗܘܐ.
(ܝܘܚ ܐ - ܓ)

This textbook aims to discuss and examine the importance of sustainability and the awareness of Green Information technologies, strategies and models. These topics have become buzzwords among users, businesses, organizations, researchers and academics as the massive increase in Information and Communications Technology (ICT) usage, and inappropriate recycling has started to harm Mother Nature. The majority of the damage has been performed by human beings; as a result, there is a need to confront this issue as soon as possible in order for the seventh generation to be able to live in similar conditions to the current generation. There is no Plan B for the planet—we must act, and we must act now!

We can tackle this problem by introducing the sustainability meaning and awareness among our new generation and discussing the new Green Information Technologies in general and examining the strategies and models which need to be adopted to minimize these problems via businesses, individuals and organizations. By integrating and practicing sustainability in all aspects of our everyday activities, we can experience many benefits: truth, beauty, moral goodness, economic opportunity, justice, liberty, physical security, cultural creativity, natural environment, a high quality of life, good education, and having our political, legal, social and technological needs met.

The practice of sustainability will make our lives healthier and stronger in our community and society. Good stewardship and ethical conduct will ultimately be rewarded, and celebration will be performed based on our actions locally and globally, and this means living with aspiration, ambition, hope and desire now as well as in the future.

Currently, to minimize ICT budgets within organizations, we need to introduce and use Green Information technologies, namely, Virtualization, Cloud Computing, Social Networking, Smart Technology, Blockchain, Drones, Robots, IoT (Internet-of-Things), 3D Printing, AR (Augmented Reality), VR (Virtual Reality), AI (Artificial Intelligence) and Big Data. Some of these technologies have already been implemented within users, businesses and organizations in developed and developing countries to make them more sustainable for their community.

Our textbook aims to discuss and examine the sustainability importance among our readers, especially in the developed and developing countries. Currently, sustainability is a buzzword with which people have become familiar via education. The majority of the authors from this textbook indicate that sustainability and Green Information technologies awareness, opportunities and challenges should consider and reflect on the duties of individuals and organizations, in order to change their mindset, attitudes and activities in order to preserve our planet. The textbook is divided into three sections, namely, Part I: Sustainability Awareness; Part II: Green Information Technology; and Part III: Green Information Awareness, Opportunities, Challenges, Strategies. The authors from this textbook come from all over the globe including Australia, Canada, China, Finland, India, Italy, Japan, Mauritius, Russia, Saudi Arabia and Taiwan.

The significance of our book aims to assist both those in the academic world, including researchers, educators and students, as well as those in the corporate world, including businesses, corporations and designers. The former will share the results of this textbook as well as new technology with their students (i.e. Masters and Ph.D.) for research purposes. For the latter, it will assist them to understand the risks and opportunities behind using sustainability and Green IT and assist in showing ways to implement these concepts in their strategies to lessen the effect of their ICT footprint and carbon emissions on our planet.

Advances in technology have led to many ways of improving sustainable ICT practices. These advances and new sustainability strategies must be spread to researchers, academics, Ph.D. and Masters students, organizations and those in the business world in order to reduce the negative influence of current ICT practices. Raw materials are being depleted at an incredible rate; we must act now to preserve these materials for future generations.

Mother Nature is suffering from our actions, and it is our duty to heal this ache or very soon it will be TOO late to save it! There is NO Plan B for the Earth; therefore, let's take care of our planet.

Perth, WA, Australia
Australia 2020

Tomayess Issa
Theodora Issa
Touma B. Issa
Pedro Isaias

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Perth, WA, Australia
Sydney, NSW, Australia

Tomayess Issa
Theodora Issa
Touma B. Issa
Pedro Isaias

Contents

Sustainability Awareness

Connected Peer Learning in Global Networks: Students' Questions About and Solutions for a Sustainable Future

Saara Nissinen, Kaija Saramäki, and Henriikka Vartiainen

Abstract The 21st century calls us to solve wicked problems that are related to sustainable development (SD). The complex and multi-disciplinary nature of SD requires collaboration in and between disciplines, education, and the wider local and global communities. In the present study, connected learning is used as an approach to enable international students' participation in collective activities where people from heterogeneous backgrounds can connect and pursue varying complex and multi-faceted problems together. Through qualitative content analysis of video messages, we illustrate the nature of the questions of 13–17-year-old participants in the World Summit of Students for Climate (WSSC) on SD and the types of actions they think are needed to solve these questions. The results of this study illustrate that the questions created by the students are factual, explanatory, and ethical by nature, and focus on a variety of perspectives related to SD. The actions created by the students require active agency at the individual, community and society levels. The number of different objects of the students' questions and actions illustrates their perceptions that actions should target many different areas of SD. We conclude with discussions on the significance of creating possibilities to promote the development of necessary competencies in current education.

Keywords Sustainable development · Connected learning · Participatory learning · Peer-Learning · Learning network · Student questions · Design-Based research

S. Nissinen (✉) · H. Vartiainen
School of Applied Educational Science and Teacher Education, University of Eastern Finland, UEF, Joensuu, Finland
e-mail: saara.m.nissinen@gmail.com

H. Vartiainen
e-mail: henriikka.vartiainen@uef.fi

K. Saramäki
ENO Schoolnet Association, Joensuu, Finland
e-mail: kaija.saramaki@enoprogramme.org

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1 Introduction

The 21st century calls us to solve wicked problems that are related to sustainable development (SD), such as climate change, which affects the lives of people all around the world (OECD 2017). The challenges related to SD should be addressed from different perspectives and in locally grounded but globally connected ways (UNESCO 2009). The complex and multi-disciplinary nature of sustainable development requires intensive collaboration in and between disciplines, education, and the wider community, along with the capacity to connect and reconcile multiple ways of looking at the world (UNESCO 2005, 2009).

In this chapter, we aim to contribute to previous research by providing an example of how to raise awareness of SD by utilizing participatory practices in a global learning context. We aim to provide insight into the types of questions globally connected youth have about a sustainable future, and the types of actions they think are needed to solve them. With this study, we aim to outline foundations for further utilization of connected learning and extended learning environments. When addressing the pressing issues of SD and the unforeseen problems of the future, there is an ever-increasing need for educating sustainability changemakers who have the knowledge, skills, values, and attitudes needed to move toward a more sustainable future (UNESCO 2009, 2017; Tobin 2016).

Education for a sustainable future call for competencies that empower individuals to reflect on their own actions, take into account their current and future social, cultural, economic, and environmental impacts from a local as well as a global perspective (UNESCO 2017). These competencies imply more than just the acquisition of knowledge and skills; future-ready students should be able to apply their own knowledge, skills, attitudes, and values to meet the complex demands at hand (OECD 2018).

As such, students should also exercise collective agency and connect their knowledge, skills, and resources to act together for a shared purpose or goal (Scardamalia et al. 2011; OECD 2018). In order to support youth to become individual and collective change agents, there is an evident need for transformative pedagogy that engages learners in participative, creative, and collective action towards a sustainable future (UNESCO 2017; OECD 2018). Becoming a change agent also requires that teachers, researchers, and policymakers listen to the students and support them to pursue complex questions that they find meaningful. To meet these challenges, this study presents the first results from the *World Summit of Students for Climate* (WSSC), where students from 70 countries acted together on climate change. In this study, our particular focus is on students' own questions and proposed solutions for creating a more sustainable future. In particular, our research questions are:

1. What types of questions do the students raise about a sustainable future?
2. What types of actions and skills do the students think are needed in solving these questions about a sustainable future?

2 Towards Connected Learning and Action for a Sustainable Future

In a world of global interconnection and rapid change, the topical challenge in the educational community is to discover new ways of educating our students to meet the challenges of today and in the future. As such, a growing number of researchers are pursuing research agendas that focus on ways of bridging formal and informal learning in a manner that serves the multiplicity of needs of all 21st-century learners (Kumpulainen and Sefton-Green 2014). According to Ito et al. (2013), such *connected learning* is realized when a young person is able to pursue a personal interest or passion with the support of friends, peers, and caring adults, and is able to link this learning and interest to academic achievement, career success, or civic engagement.

In connected learning, the students participate in collective activities where people from heterogeneous backgrounds connect with each other and pursue varying complex and multifaceted problems together (Clinton et al. 2013; Jenkins et al. 2016). Complex challenges have no single solutions; instead, they can be addressed from different perspectives (Seitamaa-Hakkarainen et al. 2010; Hakkarainen et al. 2013), and they intentionally bring into play multiple disciplines, multiple ways of working, and different habits of the mind, and community (Lombardi 2007). They also provide students with opportunities to design and perform inquiries (Krajcik and Blumenfeld 2006) and to choose different types of perspectives and paths for approaching global phenomena from the perspective of local surroundings (Nissinen et al. 2019a, b). As such, learners are held accountable for contributing to knowledge co-creation organized around complex challenges that affect their lives both at local and global (*glocal*[1]) levels (Roth and Lee 2004; Scardamalia et al. 2011; Tobin 2016).

In connected learning, students are also provided with opportunities to develop interpersonal relationships and to learn with and from their peers, teachers, and other adult mentors (Ito et al. 2013; Kumpulainen and Sefton-Green 2014; Tobin 2016). This approach involves collaborative learning and knowledge building in which students from various backgrounds actively communicate, share their expertise, make joint decisions, and work together to classify, organize, construct, and evaluate information that contributes to a common goal (Hennessy and Murphy 1999; Hakkarainen 2010; Scardamalia et al. 2011). As such, there is always the possibility for the students to contribute their ideas and insights as well as to learn how to build on other's thinking in collective problem solving and knowledge-building (Hmelo-Silver and Barrow 2008).

Connected learning also uses technology to help amplify and disseminate the students' ideas, questions, and contributions (Ito et al. 2013). Online tools and forums enable students to connect with their peers from different backgrounds, and to share and circulate their ideas and interests regardless of place and time (Jenkins et al.

[1] Subsequently referred to as glocal.

2008; Kafai and Peppler 2011). In connected learning, the aim is to provide opportunitie s and resources for students to engage in culturally and personally relevant activities that help them use their voices to affect issues they care about (Ito et al. 2013). This said, the present study focuses on video messages produced and shared by the youth participating in WSSC.

3 Method

This research is part of a larger collection of design-based research (DBR Collective 2003). The focus of our earlier research has been on the iterative development of participatory learning practices and novel learning environments, and testing them in both local and global school contexts (Vartiainen et al. 2018; Nissinen et al. 2019a, b; Liljeström et al. 2014). We have conducted design-based research in various educational contexts from early childhood education to higher education. Students and teachers have been provided with both theoretical and practical support in designing participatory and inquiry-oriented learning activities, as well as in simulating expert practices when building a solution to the challenges at hand. In the current research, we aim to build on previous knowledge by transferring the study to a global context and examining the students' collective perceptions on how to promote the creation of a sustainable future.

3.1 Participants and the Research Context

The present study was conducted during the *World Summit of Students for Climate* (WSSC), which took place on 29 May–5 June 2019 in Finland. The goal of the summit was to "raise the voice of teenagers and encourage them to act together" on climate-related issues (ENO Schoolnet Association 2019). The students' WSSC program consisted of climate-related activities (e.g., group work, discussions), field trips in the Joensuu area (North Karelia), and of the final event on World Environment Day, 5 June, in Helsinki. WSSC was organized by ENO Schoolnet Association (ENO), which is a global school and community network aimed at promoting sustainable development. Other collaborators in the event were the cities of Helsinki and Joensuu, the municipality of Liperi, the Finnish Ministry of the Environment, and the Ministry of Agriculture and Forestry of Finland, Ministry of Education and Culture, and Ministry for Foreign Affairs of Finland. The president of the Republic of Finland, Mr. Sauli Niinistö, was the patron of the summit. ENO (http://www.enoprogramme.org/) was originally established in the year 2000 in Finland, and over 10,000 schools from 150 countries have participated in the activities since then.

Altogether, 135 international students from 70 countries (Fig. 1.) participated in the WSSC. Students were invited to attend the WSSC by the ENO Schoolnet Association. The invitation was sent out to previous partners as well as new contacts.

Fig. 1 Participants on the map (ENO Schoolnet Association 2019)

The aim was to reach out to students all around the world and from each country; two student representatives, a girl and a boy together with a teacher, were invited to the summit. The participants were 13–17-year-old middle- and high-school students from all six continents. The working language of the summit was English, which was not the first language of the majority of participants. The current research activities were designed as part of the summit program. Participation in the research was voluntary, and no additional ethical review was needed. However, we respected the participating students' autonomy by asking the students and their guardians' consent for participation in the research, in the publication of the digital material produced as a part of the WSSC activities, and in the processing of collected research data. The participants also had the right to withdraw their consent at any time without an explanation. During the research, the ethical guidelines of the Finnish Advisory Board on Research Integrity (2012) were followed.

3.2 Data Collection

In this study, data used in the analysis were from short video messages produced and shared by the participants in the WSSC as part of the summit program. The students worked in small, freely formed groups of three to six members. However, the students were guided by work with peers from different countries. With this, the researchers aimed at bringing different points of view and *funds of knowledge* (Moll et al. 1992) into the conversation and as a resource for each group. Each group had about two hours for the task, which included getting instructions from the researcher, guiding the assignment, negotiating the questions, planning the video message, and filming it. During the group work, the students also had the possibility to get support from the researcher. The students were allowed to continue working on the task according to their own schedule. The final video message had to be uploaded on the Howspace platform by the end of the summit to afford the students enough time for meaningful conversation and thorough realization of the final artifact.

The participants' tasks were to: (1) create five (5) meaningful questions for the world about a sustainable future, (2) think of the types of actions and ways of thinking that are needed to answer the questions, (3) think about what key future skills are needed when making and creating a sustainable world together, and (4) to upload video messages on the WSSC web platform (Howspace). All participants in the summit had access to the video messages on the Howspace platform, but the videos were not available to the public. However, the participants were informed that their video messages were likely to be published on ENO or WSSC websites or social media. In the event the participants did not want their video message to be published, they had the right to refuse publication with no further explanation.

The task was designed to challenge the students to create inquiries about a sustainable future (Hakkarainen and Paavola 2009) and to make them collectively negotiate actions, skills, and possible solutions based on previous knowledge, experience, innovations, and future aims (Kumpulainen and Sefton-Green 2014). The phenomenon of sustainable future was chosen for this group work as it: (1) stems from the WSSC aims, (2) is a goal that needs to be acknowledged in all parts of the world, and (3) is representative of many of the ill-defined challenges in future working life.

3.3 Data Analysis

Altogether nine (N = 9) video messages were published by international students (N = 36) on the Howspace platform, equaling about 18 min and 5.5 pages of transcribed text (Times New Roman 12, spacing 1.15) for qualitative content analysis. In the first phase, one researcher transcribed the video messages verbatim. In doing so, the researcher became familiar with the data. Then, the researcher coded the students' questions into three deductive categories determined from previous research by Hakkarainen (1998): (1) *factual questions* (who, what, when, which, either-or), (2) *explanatory questions* (why, how, what-if), and (3) *ethical* questions (moral choices and dilemmas). In the second phase, these questions were further examined in terms of the phenomena in question (e.g., climate change, the use of plastic) and the main actor (individual, community, society, undefined). In the present study, the unit of analysis (see Chi 1997) was a question. For the analysis, we used free online Google tools that enabled collaboration.

In the third phase, the researcher identified and analyzed all of the students' suggested actions (N = 30) applying the same categorization (Hakkarainen 1998; Kangas et al. 2007) as in the first phase of the analysis. The categories were: (1) factual *actions* (who, what, when), (2) explanatory *actions* (why, how, what-if), and (3) design-oriented *actions* (aimed at the development of what is already known, or developing new innovations/strategies). In this context, the unit of analysis (Chi 1997) was a text segment that presented one explicit action or idea. The low number of actions is explained by the fact that some groups created one action in response to all of their questions.

In the fourth phase, one researcher analyzed students' conceptions of which key future skills are needed when making and creating a sustainable world together. However, only two of the nine videos included this part of the original learning task. Finally, two researchers checked the results, and the differences in coding were negotiated to reach consensus (Krippendorff 2004; Burla et al. 2008; Campbell et al. 2013).

4 Results

In this section, we will first give an overall picture of the students' questions and then proceed to more detailed descriptions of the nature and content of these questions. Second, we discuss the actions and skills that students think are needed in solving their questions about a sustainable future.

Altogether, the nine student groups created 48 questions about a sustainable future (Table 1). The questions were mostly explanatory (*why, how, what-if*) in nature (N = 24). The second-largest category was factual questions (who, what, when,

Table 1 Frequencies and the content of students' questions

All questions (N = 48)	Phenomena (object)	Main actor (subject)
Factual questions (N = 16)	Animals (N = 1) Clean water (N = 1) Forest fires (N = 2) Global warming (N = 1) Human actions (N = 6) Ozone layer (N = 1) Plastics (N = 3) Transportation (N = 1)	Individual (N = 4) Community (N = 4) Society (N = 0) Undefined contributor (N = 8)
Explanatory questions (N = 24)	Air pollution (N = 2) Clean water (N = 1) Climate change (N = 3) Endangered animals (N = 1) Future (N = 9) Governmental actions (N = 1) Greenhouse gas (N = 3) Plastics (N = 2) Sustainable energy (N = 1) Sustainable food (N = 1)	Individual (N = 2) Community (N = 14) Society (N = 3) Undefined contributor (N = 5)
Ethical questions (N = 8)	Values (N = 8)	Individual (N = 2) Community (N = 5) Society (N = 0) Undefined contributor (N = 1)

which, either-or) (N = 16). The analysis also revealed eight questions that were *ethical/philosophical*.

4.1 Factual Questions

The students created 16 factual questions. Six of the factual questions were *what*-questions, one was a *when*-question, two were *which*-questions, and the rest of the questions were *either-or* questions by nature. There were no *who*-questions. The students' factual questions covered such themes as global warming, clean water, forest fires, endangered animals, and human actions, for example: "What will happen to transport in the future?" and "What is the best way to protect the forest from forest fires?" These questions designed by the students revealed their interest in understanding, evaluating, and creating visions of the future, as well as their desire to seek new knowledge, actions, and ideas to promote SD.

Four of the students' questions were targeted directly to individuals. The students positioned the audience of the video messages as active contributors by connecting the word "you" to their questions: "Do you know what types of actions destroy our planet?", "Have you realized that fires are more and more frequent and harder to control?", "Do you know that animals suffer from global warming?", and "What are you doing about a sustainable future?" These four questions encompass the students' interest in understanding and reflecting the consequences of one's actions in relation to the future of our living environment. The questions also illustrate students' perceptions of our vulnerability to natural hazards and the ability to look at things from someone else's perspective. The fourth example highlights the students' desire to encourage others to reflect on their own actions about SD.

In four of the factual questions (N = 4), the students positioned themselves as main actors. The students identified a main actor as a part of society by using the pronoun "we" as in the following examples: "What can we do to prevent people from throwing waste into the oceans?", "What can we do to make our government care?", "What can we use instead of plastics?" One of the questions was directly targeted at the audience of the video message: "What are you doing about a sustainable future?" These questions illustrate both the students' ability to identify unwanted actions and their desire to demand ways of living that promote SD. The first question illustrates the students' perceptions of the importance of clean water resources, and the ability to understand the negative consequences of water pollution on a sustainable future. The second question encompasses the students' interpretation of governments' role in efforts for SD and the ability to demand governmental actions publicly. The question also illustrates the students' ability to reflect critically on governments' role in promoting SD globally. The third question indicates the students' ability to demand alternative solutions to replace harmful actions, such as using plastic. Moreover, the last question illustrates the students' competencies in awakening others to ponder their own behavior concerning promoting SD.

In most of the factual questions (N = 8), the students had not depicted a clear actor. Two of these questions focused on the prevention of harmful environmental actions, such as: "Is there any alternative to using plastics?" and "Are there any ways to stop it [global warming]?" Both of these questions reveal the students' reflection on putting a stop to environmental degradation in its different forms.

Four questions focused on promoting desirable environmental activities, as in the following: "Which individual practices have the greatest impact on creating a sustainable future?", "What is the best way to protect the forest from forest fires?", and "What way do you think is more effective to introduce the circular economy concept into our societies?" These questions demonstrate the students' perceptions of actions that promote SD, as well as their ability to seek ideas from others. The first question illustrates their interest in reflecting on the individual's impact on promoting SD. The latter questions illustrate competencies that enable taking environmental and economic impacts into account at a global level. In two of the factual questions, students intended to give voice to the audience's opinions, as in the following: "Are climate campaigns working?" and "What will happen to transport in the future?" The first question illustrates the students' ability to reflect on and evaluate existing methods for promoting SD, whereas the second question represents their abilities to envision and create alternative solutions for the future. Interestingly, the students had not created any factual questions where society had been positioned as the main actor.

4.2 Explanatory Questions

Twenty-one of the explanatory questions were *how* questions, two of the questions were *why* questions, and one was a *what-if* question. The explanatory questions covered various environmental themes, for example, climate change, air pollution, the use of plastics, clean water, sustainable energy, and greenhouse gas. The choice of a wide range of phenomena connected to a sustainable future illustrates the students understanding of the complex nature of SD. Moreover, these global phenomena were approached from the perspectives of a community ("we") and society (e.g., government, policymakers).

In two of the explanatory questions, the students positioned the viewers as active contributors and were asking for their opinion, as in the following text passage: "How do you expect the world [will be] in fifty years?" and "Do you know how it [greenhouse gases] affects our daily life?" The first question demonstrates that the students were able to comprehend the changes that might take place in a fairly long timespan, and that they were also able to invite others to share their visions about the future.

In most of the explanatory questions (N = 14), the students created the questions from the perspective of an active contributor, for example, by connecting the word "we" with the phenomena in question. For example: "How can we educate people about climate change?" "How can we slow down climate change?", "How can we achieve a green sustainable future?" While these questions were open-ended by nature, they typically focused on preventing harmful action, such as air or water pollution, a reduction in the use of plastics, and the formation of greenhouse gasses. The first question also indicates that the students' perceptions of the role of education and life-long learning as an essential means for solving problems was related to climate change and to promoting SD. Both of the questions related to climate change also reflected their ability to evaluate what kind of knowledge and actions are needed in tackling climate change. One of the questions focused on future society's perspective, as illustrated in the following excerpt: "How does the next generation see their future?" This question demonstrates the readiness to envision and evaluate a possible future but also indicates the students' interest in and ability to acknowledge the views of others. The only *what-if* question in this category illustrated the students' views of the future consequences of our careless actions: "What if we are indifferent about our planet?" This question illustrates that the students were also able and willing to communicate on difficult issues and connections between SD and our own actions.

In three of the questions, the students gave agency to government, policymakers, or industry, such as: "Why don't individuals in high positions of high power recognize climate change as a serious threat?" and "How much do the actions of industry impact the sustainable future that we always aim for?" These two questions show the students' ability to place their personal role and contribution on a larger scale consisting of local communities and global societies. Through these questions, the students illustrate their capability to evaluate and reflect on the decision-making and strategies of global leaders and industries. The remaining five questions did not present a clear contributor but were in the passive form, as in the following text passage: "What does the green mobility of the future look like?".

4.3 Ethical Questions

The analysis revealed eight questions that were ethical in nature. All of these questions included a moral choice or dilemma (e.g., continuation of current actions, changing habits). Moreover, these questions were mainly approached from the individual and community points of view. One question did not have a definite contributor.

In two of the questions, the students use the pronoun "you" to indicate the main actor as individuals. These two questions focused on causing the audience to ponder the effects of their own actions, as follows: "Are you willing to change your lifestyle for a better future?" and "Are you sure you want to live in comfort while our planet suffers drastic changes that will affect us in the near future?" These two examples encompass the students' capabilities to challenge individuals to contemplate their own consumption habits. In addition, the questions gave us a chance to get an idea of the students' own ethical views.

In five of the questions, the students used the pronoun “we” to indicate society as the primary contributor, as follows: “Will we allow melting ice to destroy all countries?”, “Which do we choose: a good future that requires quick radical actions or eventual extinction while waiting for miracles to happen?”, and “What does the Earth want from us?” One of the ethical questions did not have a clear contributor: “Is the current way of living worth saving?” These questions encompass the students’ perceptions of need to take responsibility for present and future generations. These ethical questions also demonstrate the students’ perceptions of changes that are needed in the ways of acting, thinking, and knowing. In addition, the questions reflect their understanding of the importance of their own role as a part of future sustainability changemakers (UNESCO 2017).

4.4 Actions and Ways of Thinking

The nine student groups created a total of 48 questions about a sustainable future (Table 1). The questions were mostly explanatory (*why, how, what-if*) in nature (N = 24). The second-largest category was factual questions (who, what, when, which, either-or) (N = 16). The analysis also revealed eight questions that were *ethical/philosophical* in nature. Interestingly, no design-oriented questions were created by the students.

Altogether, the student groups negotiated 40 actions or ways of thinking needed to answer the key questions about a sustainable future (Table 2). The actions were mostly factual (N = 34). The second largest category of the actions created by the students were explanatory (N = 4), and only two of the actions were design-oriented (N = 2).

Twenty-four of the actions the students suggested were categorized as *factual*. The majority of the suggested actions were more general actions to promote a sustainable future instead of providing an answer to a single question, as in the following text excerpt: “We as humans need to stop polluting our homes, to stop polluting our national environment, and in that way keep our waters and air clean for other living beings like animals and plants.” These suggested actions encompass the students’ knowledge about the complexity of SD. The actions encompass the students’ outlook that, to ensure a sustainable future, we need to work in many different areas.

The actions provided alternative suggestions for current products/practices: “There are wood products that can replace the production of plastics and some textiles which are more harmful to the environment. Waste wood can be used as bioenergy instead of fossil energy sources.” The students also provided actions with clear examples to promote more sustainable choices in everyday lives: “We should always remember to use the five R’s, which are: reduce, reuse, recycle, refuse, and replace. Save energy! For example, unplug the device you don’t need at the moment. And use a renewable energy source. For example, the sun, wind, and water.” These actions illustrate the students’ knowledge about both sustainable consumption and production. Also, these actions show their ability to adopt sustainable practices into

Table 2 Actions and ways of thinking for a sustainable future

All actions (N = 40)	Object of action	Main actor
Factual actions (N = 34)	Energy (N = 10) Transportation (N = 7) Industry (N = 1) Forests (N = 3) Sustainable products (N = 10) End polluting (N = 2) Animal protection (N = 2) Increase governmental actions (N = 6) Actions against climate change (N = 3) Environmental education (N = 3) Responsible usage of water resources (N = 2) Make investments (N = 1) Other (N = 2)	Individual (N = 7) Community (N = 16) Society (N = 7) Undefined contributor (N = 4)
Explanatory actions (N = 4)	Sustainable food resources (N = 1) Environmental activism (N = 1) Using technology for promoting SD (N = 1)	Individual (N = 0) Community (N = 2) Society (N = 2) Undefined contributor (N = 0)
Design-oriented actions (N = 2)	Novel and high-quality ways of acting	Individual (N = 0) Community (N = 1) Society (N = 1) Undefined contributor (N = 0)

their daily lives. The students' actions were also aimed at preserving fauna: "I think we can encourage people to stop using animal fur products. Also, we should take care of endangered animals. And we should stop the illegal hunting of endangered animals." These actions depict their ability and ideas on how to urge others to adopt more sustainable lifestyles. However, the students' actions were also targeted at the governmental level, as in the following examples: "And in general, the government should set higher penalties for throwing trash into the oceans," and "We think that the government can motivate people by governmental competition. When an environmental activity is changed, they should write about it on social media to spread information." The latter actions illustrate the students' competences on evaluating current governmental practices and urging governments to take the necessary actions to pursue SD. These actions also encompass the students' ability to seek solutions to bridge the gap between policy and practice.

Four of the students' suggestions for actions were categorized as *explanatory*. The difference between factual and explanatory actions was their interpretive nature. For example, in the following text excerpt the students suggest that there should be at least a certain amount of environmental education in every school, and they also provide the explanation why: “Schools should have at least one class per week to educate people about climate change and the environment, and there should be field trips to practice saving… to practice the things they learned in classes.” The students’ actions were also aimed at sustainable food production: “We can limit the amount of meat that can be purchased by people, so we can help a constant number of resources that don’t decrease or increase the damage of grass or food resources.” These suggested actions encompass the students’ ability to understand the importance of explaining how and why to practice sustainable development.

Two of the suggested actions were categorized as *design oriented*. Neither of the two design-oriented actions provided a clear or finished innovation for a sustainable future, but both actions illustrated that the students recognized the need for novel ways of acting or thinking: “A lot of money has to be invested in order to get the best modular thing in the future and the best mobility solution. And the government should support projects that are goal-oriented, and they shouldn’t stick to old measures by keeping them by any means. Maybe they have to rethink a completely new concept!” and “We must think of non-conservative and innovative ways so that we can answer these questions. The actions should be radical, quick, and eco-friendly and global. We need everyone to do a lot of things. The government of every country to do a lot of things. The market is doing a lot of things, and the civic movement that protests, questions, and challenges the government along with individuals are doing the best that they can.” In general, the design-oriented actions encompass the students’ understanding of the significance of rethinking current practices in order to realize SD. These actions also illustrate the students’ ability to understand the importance of joint development and implementation of innovative actions that promote SD at a glocal level.

The analysis of the skills students think are needed in solving the questions related to SD revealed that students mostly highlighted collaboration competencies (e.g., cooperation, support, motivating others). Collaboration competencies are intrinsically linked to an individual’s ability to work in a team and utilize the skills and perspectives of others to achieve shared SD goals (UNESCO 2017). Students also called for systems-thinking competencies (e.g., adaptability, braveness, and hopefulness). These skills are essential to be able to deal with uncertainty (UNESCO 2017). Student actions also reflected the need for anticipatory competencies (e.g., innovation and creativity). Anticipatory competencies play a significant role in understanding and building one’s own future visions and goals for SD. The actions created by the students also reflected normative skills (e.g., knowing and learning about nature). Finally, to implement the activities related to SD, self-awareness competencies (e.g., determination) also are required. These skills are essential for an individual to reflect on their own knowledge, skills, and role concerning promoting SD.

5 Discussion

The goal of this study was to explore the nature of students' questions about a sustainable future, and furthermore, the actions needed to solve the questions. In the present study, we designed an open-ended assignment for international WSSC participants in which a sustainable future served as the object for the students' joint learning activities. Our analysis revealed the nature of students' questions about SD (see Hakkarainen 1998) and the main actors in the implementation of the actions. The analysis also revealed the diverse phenomena that were at the heart of students' reflection on SD. From this perspective, we have drawn conclusions on students' perceptions of the actions needed in solving glocal challenges to SD.

Regarding the first research question "*What kind of questions did the students raise about a sustainable future*?" the analysis revealed that students created mostly explanatory questions. These questions addressed a sustainable future through many different phenomena, such as climate change, greenhouse gas, and the use of plastics. The large number of different phenomena in the questions created by the students indicates that the students recognized the complexity of the phenomena related to SD. In most of the explanatory questions, the students emphasized that everyone must play their part to promote a sustainable future (c.f. UNESCO 2017). The second form of questions was factual. The factual questions also addressed a variety of themes of SD (e.g., human actions, forest fires, and clean water), and most of these questions reflected the importance of the community in achieving a sustainable future. In addition, the students formed eight ethical questions that were linked to values, and in the present study, the students identified the community as the main actor. As such, these questions indicate that the students desired to foster SD values as a part of communal actions.

Regarding the second research question, "*What kind of actions and skills do students think are needed in solving these questions about a sustainable future*?" our analysis revealed that most of the designed actions were factual in nature (e.g., stop polluting, save energy, use sustainable products). However, the students' questions reflected various different objects of actions (e.g., energy, sustainable products, transportation). Interestingly, the objects related to explanatory actions differed slightly from the phenomena in other categories (e.g., sustainable food resources, environmental activism, using technology for promoting SD). The explanatory actions contained an interpretive nature aimed at answering *how*, *why* or *what-if* questions (e.g., promoting sustainable food resources to decrease environmental harm). Finally, two design-oriented actions were found. The design-oriented actions illustrated that the students recognized the need for novel ways of acting or thinking (e.g., pursuing novel and high-quality ways of acting). In all, these necessary actions presented by the students highlighted the role of community and society in implementing the activities that the students perceived as meaningful. As such, these actions designed by the students also reflected a very broad range of competencies needed for future change makers, such as collaboration, systems thinking, anticipatory competencies, and self-awareness competencies (UNESCO 2017).

6 Conclusions

To achieve SD goals, we all need to reflect and change the way we live and consume (UNESCO 2017). In addition, we also need to empower youth to use their knowledge, skills, and ideas to build a better future. In order to enable youth to develop these skills that will be needed in the future, we must provide them with education which develops a broad range of skills and competencies (Scardamalia et al. 2011; UNESCO 2017). According to UNESCO (2017) these multifunctional skills include knowledge and thinking skills related to SD, knowledge and skills that enable efficient collaboration with others, and skills needed in designing and implementing actions related to SD. Future change-makers also need to develop global competencies to manage the increasing uncertainty, social diversity, economic, and cultural uniformity, and the rapid technological development that all embody our current and future society.

If the future of sustainable living and working is based on global collaboration and actions towards SD, educational should provide opportunities for students to develop such competencies that will prepare learners for meaningful and productive lives. Accordingly, students should work in international teams on complex challenges that rise from the real world. In this study, we asked the students to work together and create questions they think are relevant for SD. In line with the connected learning approach (Ito et al. 2013), the students designed their questions with their peers and in surroundings that provided to abundant resources and networked connections. As such, these questions are products of international peer-collaboration where the youth acted together to raise their voices.

Like all research, this study has its limitations. Particularly as the amount of video data for analysis purposes is fairly small. The research took place during the WSSC Summit leaving only a little time for data collection. However, the video messages that were available for research purposes, were made by students from different parts of the world, so the material reflects the thoughts of international students.

The need for research on what kinds of international networks emerge from glocal collaboration (e.g. WSSC Summit) has been identified. The network perspective and how international networks affect students' perceptions of SD will be further investigated by the author(s) with the same research population.

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Life Cycle Approach for Sustainability Competence Assessment

Alexander A. Voronov

Abstract Our efforts are devoted to the problem of sustainability competence assessment by the appropriate questionnaire. The essential role of quantity is known for understanding the challenges at sustainability, and among the attempts to capture its main features and quantities the sustainability performance indicators technique based at the concept of life cycle thinking is tested. Our life-cycle approach for modelling issues at sustainable development paradigm is represented, and it provides us with well based qualitative and quantitative outlook at sustainability challenges. Particularly, the sustainability competence assessment of youth and business activities with total sustainability score is undertaken. Our results are concerned to the following themes: (a) the family of questionnaires to assess the sustainability competence probability, based on measuring wellbeing, efficiency and safety, as well as monitoring framework for the sustainable development goals; (b) the model outlook on the complexity of cognitive strategies based on the transformation theory of learning for adequate interpretation of the provided assessments, which are applicable to many kinds of human activities; (c) the dissemination principle has been reviewed as a sustainability implementation mechanism when the sustainability mode is adopted by the major part of the stakeholders being above some threshold level.

Keywords Sustainable development · Sustainability competence · Product life cycle · Production and technology factors · Human factors · Demand and supply · Cost function · Utility function

List of Acronyms and Abbreviations

CSA	Corporate Sustainability Assessment Methodology
DJSI	Dow Jones Sustainability Indices
EP	Education Programs
GfS	Generation for Sustainability

A. A. Voronov (✉)
International Centre for Information and Analytics, UNECON, Saint-Petersburg, Russia
e-mail: Voronov.a@unecon.ru

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GMI	Global Monitoring Indicators
HE	Higher Education
HS	High School
ICT	Information and Communications Technology
IPLC	Integrated Product Life Cycle
LC	Life Cycle
LCI	Life Cycle Initiative
LCM	Life Cycle Management
LCT	Life Cycle Thinking
MFSDG	Monitoring Framework for the Sustainable Development Goals
MCSP	Market Conjuncture Sustainability Problem
MKAB	Measuring Knowledge, Attitudes and Behaviors
PLC	Product Life Cycle
PS	Primary School
RSCP	Rate of the respondents with the Sustainability Competence Probability not less of the critical level
PCU	Psychological Complexity Unit
SC	Sustainability Competence
SCP	Sustainability Competence Probability
SD	Sustainable Development
SDGs	Sustainable Development Goals
SETAC	Society for Environmental Toxicology and Chemistry
TBL	Triple Bottom Line
TSS	Total Sustainability Score
UNEP	United Nations Environment Programme
WFL	Weber-Fechner Law function
YSCP	Youth Sustainability Competence

1 Introduction

Within the strategic challenges of the 21st century there are the clear signals that "business-as-usual" cannot continue. The Earth System is passing into a new phase of human experience that will be qualitatively and quantitatively different from the one we have known, and with the urgent demand for sustainable development. Manufacturing at the new century is becoming automate and service-driven by digital platforms, and industry is changing into low-cost onsite manufacturing. These will cause drastic changes to the structure of industry and society. Answering the challenges, we need to make sure that economy can thrive in this change. We have not only to envision a roadmap of how high-tech manufacturing will change, but also show what are the key technological and societal drivers that control this change, and explain what kind of business, educational, and societal models are needed to ensure that business companies are able to survive and reap the most benefit from this revolutionary change.

Throughout history, education has been considered a powerful tool for meeting the competence answering the challenging tasks in any society. It has been established that the economic policies would only be efficient if they are accompanied by adequate policies in the field of education. The new kind of competence is desired to play a key role in securing social cohesion, prosperity, and sustainability in the long term. In this sense, lifelong learning has become the umbrella for all prospective training programs and initiatives for sustainability competence. In recent years a lot of prominent committees and organizations have addressed the shortcomings in education towards sustainability sciences, new standards, guidelines, and benchmarks designed to serve as blueprints for a systemic reform. Currently it is agreed that adequate curricula should focus on reasoning and problem-solving rather than memorization, and that science should be presented as an active process of investigation aimed to manage the future rather than a set of facts and static theories. These efforts tried to open a new page in getting closer to the research design which gives ideas for scholars on "research on demand"—in whatever faculty one may be. Such kind of approach demands a lot of planning for the execution of learning tasks: the movement known better as "constructivism", or the team-work known as "social constructivism". It emphasizes the fact that students build new competence in the ways integrated with their existing cognitive structures and through exercising the modes of inferences, "connection-making of meaning-making".

So, in practice there is need to study how lifelong learning could support sustainability. A bulk of publications on environmental, social and economic themes has been turned into consideration which measures can be best used for sustainability competences practicing. The desired assessment at our version has the form of "Sustainability Competence Probability". Where the "competence" is mentioned as being able to perform a work role to a defined standard, with reference to real working environments (in accordance to "International Education Standards for Professional Accountants/October 2003").

Towards the noted above problems in the part of sustainability competence assessment the known conception "Life Cycle Thinking" provides wide prospects to follow promising sustainability paradigm. Based on the multi-criteria approach the models for life cycle chain within its economic, environmental, and social criteria through the innovative market instruments towards combining private and public interests are at the design. Life cycle approach is used also to analyze transforming the human resources and innovations matched to the lifelong learning for sustainability with the objective of qualitative helping individuals and companies along the value chain to contribute to informed decisions for sustainable development, and to act upon these decisions. And the last ones provide the strong basis for implementation of the sustainability competence assessment. Based at these approaches and having in mind the concept of life cycle thinking, we can follow the activities towards the application of life cycle instruments to encourage the sustainability competence.

It is well known that questionnaire tests can serve as powerful incentives to prompt working towards centrally established quality outcomes. Our efforts are devoted to the problem of sustainability competence assessment by the appropriate questionnaire. Sustainable development is the subject of extreme complexity. The essential role of quantity is known for understanding the challenges at sustainability, and among the attempts to capture its main features and quantities the sustainability performance indicators technique based at the concept of life cycle thinking is tested. Our life-cycle approach for modelling issues at sustainable development paradigm is represented, and it provides us with well based qualitative and quantitative outlook at sustainability challenges. Particularly, the sustainability competence assessment of youth and business activities with total sustainability score is undertaken. Our results are concerned to the following themes: (a) the family of questionnaires to assess the sustainability competence probability, based on measuring wellbeing, efficiency and safety, as well as monitoring framework for the sustainable development goals; (b) the model outlook on the complexity of cognitive strategies based on the transformation theory of learning for adequate interpretation of the provided assessments, which are applicable to many kinds of human activities; (c) the dissemination principle has been reviewed as a sustainability implementation mechanism when the sustainability mode is adopted by the major part of the stakeholders being above some threshold level.

2 Life Cycle Conception at Sustainability Problems

2.1 Life Cycle Thinking Approach

The United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched in 2002 an International Life Cycle Partnership, known as the Life Cycle Initiative (LCI), to enable users around the world to put life cycle thinking into effective practice. The Initiative responds the call by Governments around the world for a Life Cycle economy in the Malmö Declaration (2000). It contributes to the 10-Year Framework of Programmes to promote sustainable consumption and production patterns, as requested at the World Summit on Sustainable Development (WSSD) in Johannesburg (2002). The Life Cycle Initiative aims to promote life cycle thinking globally and facilitate the exchange of knowledge of over 3,000 experts worldwide and networks from different continents. Life Cycle Networks provide a node for people and projects. Regional, National and other networks are independent, but supported by the Life Cycle Initiative (Valdivia et al. 2011). There are three basics components in LCI:

- Life Cycle Concepts—A category of Life Cycle Approaches that guide and inspire the analytic and practical applications of Life Cycle Approaches, which includes Life Cycle Thinking and Life Cycle Management;
- Life Cycle Tools—A category of Life Cycle Approaches that support decision making by modelling and analyzing data over the life cycle of a product;

- Programmes—Paths to make sustainability operative providing the strategy and the appropriate actions to be taken, putting Life Cycle Approaches into practice.

Life Cycle Thinking (LCT) is the primary concept; it seeks to support our steps toward sustainability describing a system across all life cycle stages, to identify possible priorities of interventions based on the areas where most opportunities exist and avoiding burden shifting. It is about understanding the environmental, social and economic impacts we manage when we are making decisions. The other key concept is Life Cycle Management (LCM), which is the systematic integration of life cycle thinking into managerial practices. This means to manage the whole life cycle of a system. "System" may be a product (being as goods, services, technologies), process, even an organization with the aim of providing societies with more sustainable products. The most effective way of supporting our decisions toward sustainability is the application of these concepts combined with the existing tools for assessment.

Four-stages material flow through mining, production, consumption and utilization summarizes the Life Cycle (LC) concepts and tools that we have previously described. From the vision and guide that concepts provide, we can see how the application of different life cycle tools, supported by data and knowledge, can give us the way to assess the environmental, social and economic impacts and benefits. One step further will be to combine the evaluation of these impacts and benefits and integrate all of them in the decision-making processes. The tool emerged as a response to the integration challenge and covers the three dimensions of sustainable development is the Life Cycle Sustainability Assessment.

Going to model the above noted issues, let's clear some formal elements. Indeed, "sustainable development" is the state of economy with compromise in the appropriate sense among economic, environmental, social, and institutional objectives, with the notation: "Sustainable Development, SD" = providing Sustainable Consumption and Production. This option admits equivalence between "sustainability" and "sustainable production and consumption" in respect to economic, environmental, and social criteria. In turn, "Sustainable Consumption and Production" = Product Life Cycle which is assumed under Triple Bottom Line for the benefit of both sides, now and in the future, where: "Product Life Cycle, PLC" = product stages at the chain of "Mining" (M), "Production" (P), "Consumption" (C), and "Utilization" (T) activities. And: "Triple Bottom Line, TBL" = vector optimization problem with economic, environmental and social objectives (R—public, Q—private). The concept of Triple Bottom Line that is understood as similarly to the 3P approach: Profit (= Efficiency), People (= Wellbeing), and Planet (= Safety) is represented by damage power with $R \to \min$ (public interest), and by profit and utility criteria with $Q \to \max$ (private interest). So, there is the model for SD, as the equilibrium in the life cycle chain (structure with specific parameters and criteria):

$$\mathrm{SD} = \mathrm{PLC}(\mathrm{M}, \mathrm{P}, \mathrm{C}, \mathrm{T})\Theta\mathrm{TBL}(\mathrm{R}, \mathrm{Q})$$

Here "Θ"—is symbolic notation for the composition, provided by Pareto optimization.

2.2 Product Life Cycle Modelling

Along the attempts to capture the main features and quantities in sustainability problems towards the questionnaire development the Sustainability Performance Indicators technique is well recognized after ten-years history of Life Cycle Thinking. Within the rational heuristic approaches now are available the instruments, well agreed to the market conceptions. Relating to the LC model, our basic approach is followed by the specification of preferences and production sets and conception of "perfect competition" in the sense that each producer and consumer regards the prices paid and received as independent of his own choices (Arrow and Debreu 1954). Based on the multiple-criteria technique, the model of the life cycle chain has been tested (Voronov 2007, 2011). LC model is the state of economic system at any points of time as the solution of a system of simultaneous equations representing the demand for goods by consumers, the supply of goods by producers, and the equilibrium condition that supply equal demand on every market and each producer and consumer acts so as to maximize his profit. An equilibrium in the market is a price and product allocation such that for each demand and supply, correspondently, the preference-maximizing and the profit-maximizing with the balance condition are provided. The private agents in the life cycle chain have profit and utility functions, and the material flow is designed in balance of demand and supply driving forces. And, at the next step of our approach, by multi-criteria optimization tool the cost functions and the utility functions for the noted preferences and profits could be introduced (Voronov 2018):

$$\mathrm{i} = 1 \div \mathrm{I},\ \mathrm{QM}^{\mathrm{i}} = \left(\pi^{\mathrm{M}}, \mathrm{m}^{\mathrm{i}}\right) - \mathrm{CM}^{\mathrm{i}}\left(\mathrm{m}^{\mathrm{i}}\right)$$

$$\mathrm{j} = 1 \div \mathrm{J},\ \mathrm{QP}^{\mathrm{j}} = \left(\pi^{\mathrm{P}}, \mathrm{p}^{\mathrm{j}}\right) - \mathrm{CP}^{\mathrm{j}}\left(\mathrm{p}^{\mathrm{j}}\right) - \left(\pi^{\mathrm{M}}, \mathrm{M}^{\mathrm{j}}\mathrm{p}^{\mathrm{j}}\right)$$

$$\mathrm{k} = 1 \div \mathrm{K},\ \mathrm{QC}^{\mathrm{k}} = \mathrm{CC}^{\mathrm{k}}\left(\mathrm{c}^{\mathrm{k}}\right) - \left(\pi^{\mathrm{P}}, \mathrm{c}^{\mathrm{k}}\right) - \left(\pi^{\mathrm{T}}, \mathrm{T}^{\mathrm{k}}\mathrm{c}^{\mathrm{k}}\right)$$

$$\mathrm{l} = 1 \div \mathrm{L},\ \mathrm{QT}^{\mathrm{l}} = \left(\pi^{\mathrm{T}}, \mathrm{t}^{\mathrm{l}}\right) - \mathrm{CT}^{\mathrm{l}}\left(\mathrm{t}^{\mathrm{l}}\right)$$

Here are: CM, CP, CT—costs (mining, production, utilization), and CC—utility (consumption) with $\partial C > 0$, and $\partial^2 C > 0$ (mining, production, utilization), and $\partial^2 CC < 0$; also, m, p, c, t–resource, product produced, product consumed, waste; $\pi^{M, P, T}$—price vector; and here is (a, b)—inner vector multiplication and $\partial^2 C > 0$—positive determined matrix (< –"negative"). There are material equations:

$$\Sigma \mathrm{m}^{\mathrm{i}} = \Sigma \mathrm{M}^{\mathrm{j}}\mathrm{p}^{\mathrm{j}},\ \Sigma \mathrm{p}^{\mathrm{j}} = \Sigma \mathrm{c}^{\mathrm{k}},\ \Sigma \mathrm{T}^{\mathrm{k}}\mathrm{c}^{\mathrm{k}} = \Sigma \mathrm{t}^{\mathrm{l}}$$

with M^j, T^k—specific rates for resource consumption, and waste production. Every market in the life cycle chain is provided by the agents of two types: supply, with private criteria QS(X), and demand, with private criteria QD(Y). By the targets

{QS(X) → max} & {QD(Y) → max}, the multi-criteria model at the every stage is introduced. It could be solved like this: Q(π, X, Y) → max, where Q is a linear normalized combination of supply and demand criteria. The multi-criteria technique provides equations for the equilibrium point (π_o, Z_o), which belongs to the Pareto set. Based on LCT, for every market with supply (X) and demand (Y), the negative release could be accounted, which is represented by a damage power, modelled by a risk function R(X, Y) after social and environmental impact. This triple optimization meets the equilibrium of private and public interests in the economic equivalence for CM, CP, CT, and CC after the damage term (Voronov 2018):

- There is a function in the form of cost, reflecting supply risk, RS;
- There is a function in the form of utility, reflecting demand risk, RD.

The multi-criteria optimization provides the issue, combining private and public interests: {QS(X) → max} & {QD(Y) → max} & {RS(X) → min} & {RD(Y) → min}. Here are the private targets of supply and demand activities for profit and utility maximization, while the public component is under desirable minimum for the damage.

Product Life Cycle model is represented by using economic, environmental, and social criteria and the innovative market instruments for combining private and public interests. The value chain for LC consists of four stages—resources mining with business activities {M_i}, production {P_j}, consumption {C_k}, wastes utilization {T_l}, and provides three product markets: resources (M), goods (P), and wastes (T). Every market has supply and demand interests (private) as well as environmental and social interests (public). Two groups of criteria will control the noted markets: economic (by supply and demand), and environmental and social (by damage power). At the task of sustainability modelling, we have the 4-dimensional network with the sites (M_i, P_j, C_k, T_l).

Dynamic analysis of the positions and characteristics of market equilibrium is by far the most widely accepted mode of economic theory. The importance of dynamic foundations is well known, because if the equilibrium model is to be of any use then we must have some confidence that the system is stable, i.e. that it must converge into some stable mode after initial conditions. And here is used notation "sustainable market":—equilibrium exists, is unique and asymptotic stable in accordance to private and public criteria. These conditions provide stability of the market system, represented by the life cycle chain. In such a view, PLC network is becoming a kind of "self-organizing" system that is able to change structure and function in response to external circumstances towards sustainable market.

2.3 Market Threshold Phenomenon

Methods and results of percolation research have a relationship with the structure of complex networks and its dynamics (Christensen 2002). At such approach we can apply the "site percolation model". The cluster is a connected component in the set of sites. For finite network, it is seemed, that if the occupation probability p is small, then there is only a very tiny chance of having a cluster percolating between two different boundaries, and for p close to 1, we almost certainly will have a cluster percolating through the system, i.e., “percolating cluster”. The network is said to percolate if there is the percolating cluster. At the case of 4-dimensional network $\{M_i, P_j, C_k, T_l\}$ it could be shown that there is critical probability ($p_c = 0.20 \pm 0.01$), tractable as the threshold, above which the percolating cluster appears.

At such a view it could be the “sustainable site”, i.e., it contains three sustainable markets for resources, goods and wastes, or “not sustainable” with probabilities “p” and “$1 - p$” respectively. So, we claim that if the sites at the 4-dimensional network $\{M_i, P_j, C_k, T_l\}$ are sustainable with $p > p_c$, then the percolating cluster appears, and the PLC network in a line with the conception of “perfect competition” becomes global sustainable. So, starting from criteria $QM^i \to \max$, $QP^j \to \max$, $QC^k \to \max$, $QT^l \to \max$ and $RM^i \to \min$, $RP^j \to \min$, $RC^k \to \min$, $RT^l \to \min$, we can define three optimization tasks in view of the materials equations for each of three markets at PLC:

$$\max_{X,Y} H_{M\&P,P\&C,C\&T}(X, Y)$$

$$H = \Sigma D^j\left(Y^j\right) - \Sigma S^i\left(X^i\right)$$

Here are used: M&P—material-production, P&C—production-consumption, C&T—consumption-treatment markets; D^j—demand utility, S^i—supply cost; and $1 \le i \le I$, $1 \le j \le J$.

Unique equilibrium existence of the (I, J)-market will be available with the conditions A&B (Voronov 2018):

$$A : \Sigma(\partial D^j(0), U^j) - \Sigma(\partial S^i(0), V^i) > 0$$

$$B : \Sigma(\partial D^j\left(Y^j\right), U^j) - \Sigma(\partial S^i\left(X^i\right), V^i) < 0$$

$$\Sigma D^j\left(Y^j\right) - \Sigma S^i\left(X^i\right) = 0$$

For example, having $\dim X^i = \dim Y^j = n$ and $I, J > 1$, at A-case we need for existence of parameters $\{V^i, U^j\}$ that one is confirmed by relation:

$$C^{n+1}_{n(I+J)} \ge I * J + n(I + J)$$

In turn, at B-case we need for existence of parameters $\{X^i, Y^j, V^i, U^j\}$ that one is confirmed by relation:

$$C^{2n+2}_{2n(I+J)} \ge I * J + 2n(I + J)$$

In adds, if $I \neq J$, we need to include (I/J)-factor. But in practice, there is $I \sim J$ that is supposed for the model of "perfect competition".

The similar circumstances are used at the discussion relating sustainability at the material (M&P), product (P&C) and waste (C&T) markets that one will be available with the conditions (e.g., A-case) between the appropriate supply costs (S) and demand utilities (D):

$$\begin{aligned}&\Sigma\left(\partial CC^k - \partial RC^k,\ c^k\right) - \ \Sigma\left(\partial CT^l + \partial RT^l,\ t^l\right)\\ &\quad - \ \Sigma\left(\partial CM^i + \partial RM^i,\ m^i\right) - \ \Sigma\left(\partial CP^j + \partial RP^j,\ p^j\right) > 0\end{aligned}$$

The noted inequality is resulted as the unique equilibrium existence condition for PLC. In turn, our claim follows after the asymptotic stability of PLC that is in accordance with the price-dynamics approach (Arrow and Hurwicz 1958):

$$\frac{d\pi^M}{dt} = \sum M^j p^j - \sum m^i;\ \left(F^M\right)$$

$$\frac{d\pi^P}{dt} = \sum c^k - \sum p^j;\ \left(F^P\right)$$

$$\frac{d\pi^T}{dt} = \sum T^k c^k - \sum t^l;\ \left(F^T\right)\text{and}$$

$$\frac{dV(\pi)}{dt} < 0$$

Here are used m^i, p^j, c^k and t^l as solutions for $\partial QM^i = \partial RM^i$ & $\partial QP^j = \partial RP^j$ & $\partial QC^k = \partial RC^k$ & $\partial QT^l = \partial RT^l$. Having Lyapunov function $V(\pi) = (F^M, F^M) + (F^P, F^P) + (F^T, F^T)$, due the price dynamics, the asymptotic stability condition is provided.

The same threshold assessment is also supported by market modelling with 2-dimensional network (Supply-Demand) that having critical probability $p_c \approx 0.59$, Figs. 1 and 2 (Christensen 2002).

In such a view, due the known existence and stability results from the fundamental theorems of general equilibrium (Maskin and Roberts 2008) there is possible the other version of sustainable market, e.g., existence and local stability of equilibrium.

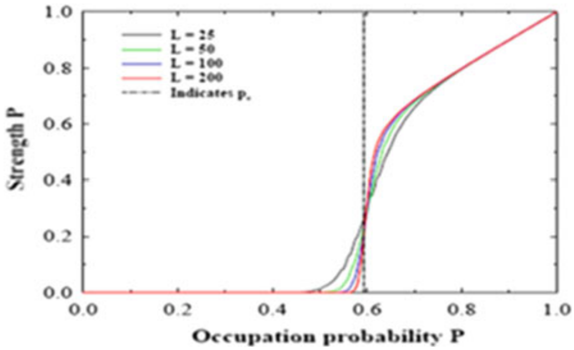

Fig. 1 "Strength of cluster, P(p)"—probability site belongs to percolating cluster is measured in 2d square lattice for finite system

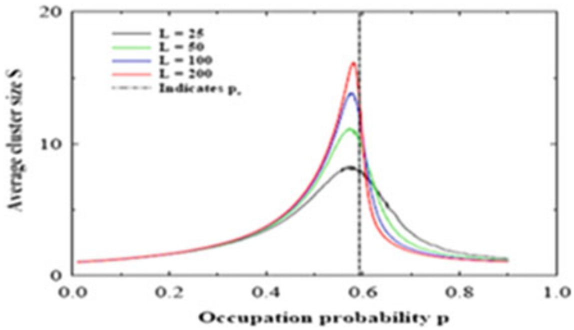

Fig. 2 The average cluster size S(p) measured in a 2d square lattice for finite system sizes L as a function of occupation probability p

3 Methods

3.1 Sustainability Competence Probability

The designed assessment has the form of "Sustainability Competence Probability" (SCP). Where the "competence", as it was noted before, is mentioned as being able to perform a work role to a defined standard, with reference to real working environments. In accordance with above said, the competence refers to the demonstrated ability to perform relevant roles or tasks to the required standard. Whereas capability refers to the attributes held by individuals that give them the potential to perform, competence refers to the actual demonstration of performance. Competence may be assessed by a variety of means, including workplace performance, workplace simulations, written and oral tests of various types, and self-assessment.

Our approach is introduced under the strategy network concept that starts from "knowledge", generated by lifelong learning system for professional competence aimed to sustainable development, through "innovations", as the market competitive advantages based on research and technology developments, to "infrastructure", being cooperative efforts for effective activities allocations. Sustainable Development, as it was treated above (refer: Sect. 2.1 Life cycle thinking approach), belongs to the conjunction of the strategic sustainability perspectives Wellbeing, Safety and Efficiency, which are characterized by probabilities Q_W, Q_S, Q_E for "ability to perform" by respondent (e.g., student, company, etc.) relevant roles or tasks to the required sustainability. The last ones later are treated as "probabilities of right decision". So, in accordance to undertaken modelling we have:

$$SCP = Q_W * Q_S * Q_E$$

The expression for Assessment of Sustainability Competence Probability (ASCP) is based at statistic approach. Indeed, because if M is the number of right decisions at the experiment with the power of N independent issues, then such result has the probability P(M, Q, N) ~ $Q^M(1 - Q)^{N-M}$, with the parameter "Q" for the probability of right decision. So, maximum of P(M, Q, N) by Q is M/N that is the best experimental assessment for the probability of right decision. At last, ASCP(r) for the respondent "r" is:

$$ASCP(r) = \left(\frac{RW(r)}{|W|}\right) * \left(\frac{RE(r)}{|E|}\right) * \left(\frac{RS(r)}{|S|}\right)$$

Here are used: RW, RE, RS—numbers of right decisions at the experiment of the independent issues, relating to Wellbeing, Efficiency, and Safety (here |A|—power of the set A). And ASCP is the multiplication of the experimental assessment for the probabilities of right decisions. So, ASCP could be used to assess sustainability competence probability SCP(r) of respondent, being or going in practicing of life cycle sustainability.

In turn, there is need to provide conjunction between the objective market data (probability of PLC sustainability, γ) and individual psychological data (sustainability competence probability, δ). Here is used S-type function, following Weber-Fechner Law for "doze (δ)-effect (γ)" simulations, and $\gamma = WFL(\delta)$. By the first law of Ergodynamics the work efficiency is a bell-shaped function with the factor of mutual adaptation between human work functionality and work environment (Venda and Hendrick 1994). Maximal work efficiency is reached when the work functionality and the work environment are mutually adapted. Very often the first law is visualized as a parabola curve, and at this way with the side conditions for the function "WFL" and its derivative: $WFL(0) = 0$, $WFL(1) = 1$, $WFL'(0) = 1$, $WFL'(1) = 0$, one can find (Voronov 2019):

$$WFL(\delta) = -\delta^3 + \delta^2 + \delta, 0 \le \delta \le 1$$

In turn, the noted probability SCP along the life cycle thinking is in the strong adjustment with three markets (M, P, T), being in sustainable mode everyone with the probabilities $p_{M, P, T}$: $p_c \le p_M * p_P * p_T$. And now we can define the low border for the threshold value of Sustainability Competence Probability (SCP_c) by the relation: $p_c^{1/3} = WFL(SCP_c)$ and $p_c = 0.20 \pm 0.01$. The tested calculations have showed: $SCP_c \approx 0.47$. In adds, due 2-dimensional network (Supply-Demand) simulation that having critical probability $p_c \approx 0.59$ (refer: Sect. 2.2 Market sustainability and threshold phenomenon), once more we have $SCP_c \approx 0.47$, as it is $0.59 \approx WFL(0.47)$.

Below we've undertaken the family of methods to measure the sustainability competence probability in accordance with life cycle thinking and threshold phenomenon.

3.2 *Design of Questionnaire: Principles and Procedures*

At looking for the development of questionnaire to assess the sustainability competence, we've reviewed the accepted reports "Measuring Knowledge, Attitudes and Behaviors towards sustainable development, MKAB" (MKAB 2009), and "Indicators and a Monitoring Framework for the Sustainable Development Goals, MFSDG" MFSDG (MFSDG 2015).

Our starting point is to develop a questionnaire, based at "MKAB". And here it was mentioned along the competence treatment: "Knowledge"—all that is known, an organized body of information; "Attitude"—a way of thinking or behaving; "Behavior"—a functioning in some specified way and stressing the importance of sustainability factors in determining these acts. The framework lists the strategic sustainability perspectives (W, S, E), and their conjunction provides sustainable development. As the example, these ones are the following:

"Wellbeing perspectives, W", including

- human rights,
- peace and human security,
- gender equality,
- cultural diversity and intercultural understanding,
- health,
- HIV/AIDS,
- governance;

"Safety perspectives, S", including

- natural resources (water, energy, agriculture, biodiversity),
- climate change,
- rural development,
- sustainable urbanization,
- disaster prevention and mitigation;

"Efficiency perspectives, E", including

- poverty reduction,
- corporate responsibility and accountability,
- market economy.

Tests of respondent's knowledge, attitude and behavior concerning sustainable development should reflect the topics included in this list. The top-rated items from the noted three sets, 15 items measuring Knowledge (K-set), and 15 each measuring Behavior (B-set) and Attitude (A-set, example: Table 1, An—item number, ω—statement) have been tested.

The decision predicate ("P") is used by the respondent: P(ω) = True (T), if his opinion of item statement "ω" is in agreement with the sustainability paradigm, and P(ω) = False (F) if his opinion of this statement "ω" is not agreed with the sustainability paradigm. Example of a procedure:

- "Knowledge"
  P(ω) = T/F; ω = "Economic development, social development and environmental protection are all necessary for sustainable development".
- "Attitude"
  P(ω) = T/F; ω = "There is no point in getting involved in environmental issues, since governments and industries have all the power and can do what they like"
- "Behavior"

Table 1 Attitudes concerning sustainable development (A-set)

A	ω
A1	Every girl or boy should be taught the knowledge, values, issues and skills for sustainable development
A2	We should be sure that the next generation inherits a community at least as healthy, diverse and productive as it is today
A3	It is OK for companies to make products that are designed to be thrown away after one use
A4	Using more resources than we need is a serious threat to the health and welfare of future generations
A5	Laws and rules to protect the environment do not need to be more strict than they are now
A6	Reducing poverty is an important topic in education for sustainable development
A7	Sustainable development will not be possible until richer nations stop exploiting the workers and the natural resources of poorer countries
A8	Companies that are environmentally responsible are more likely to make a profit over the long run
A9	The teaching of living sustainably should be included in all subjects in all grades
A10	Governments should encourage greater use of fuel-efficient vehicles
A11	To continue to be one of the best countries in the world to live in, RF must make sustainable development a priority
A12	Learning about citizenship is an important part of learning about sustainable development
A13	Taxes on polluters should be increased to pay for damage to communities and the environment
A14	There is no point in getting involved in environmental issues, since governments and industries have all the power and can do whatever they like
A15	Gender equality has nothing to do with sustainable development

$P(\omega) = T/F$; $\omega =$ "I have changed my personal lifestyle to reduce waste".

The experimental data have elements "T" or "F". Based on the noted data, it will be possible to assess for every respondent the current (before/after training) sustainability competence probability by ASCP(r). Here is mentioned wellbeing (W-set), efficiency (E-set), and safety (S-set) sets are contained at the Sum-Set = {K-set} U {A-set} U {B-set}; $P = (|W| + |E| + |S|)/3$—"power" of questionnaire, and U—symbol for joining of the sets.

The next step of our design is devoted to "quality" of the decision rule via variations, based at the report "MFSDG". Here the quality is measured as inverse to the average square deviation (σ^2) of the experimental probability. As example, for 17 Sustainable Development Goals (SDGs), G_g, $1 \leq g \leq 17$, there are used 100 associated indicators, I_i, $1 \leq i \leq I = 100$ (currently there are known already about 230 Global Monitoring Indicators, GMI). There is assumed the allocation of indicators to the goals, and "definition" for every indicator. The questionnaire concept is based at the knowledge "To what goals does the current indicator match?". The sets W, S and E of "items" concerned to Wellbeing, Safety and Efficiency could be produced. Everyone item could be matched to some of 17 SDGs, and the option for respondent is the allocation choice that could be "right" or not. As an example, at the design for the questionnaire, based at MFSDG, it could be used:

- Goals' presentation (G_1–G_{17});
- Indicators' presentation (Wellbeing W_1–W_{49}, Efficiency E_1–E_{27}, Safety S_1–S_{24});
- Filling the Decision Table by each of R respondents "$r \in R$": {RW(r)}, {RE(r)}, {RS(r)}
- Calculating the Assessment for Sustainability Competence Probability.

Questionnaire part "Wellbeing": $\{W_i\}$, $\{G_1–G_6\}$—the appropriate indicators and goals. Questionnaire part "Efficiency": $\{E_i\}$, $\{G_7–G_{12}\}$—the appropriate indicators and goals. Questionnaire part "Safety": $\{S_i\}$, $\{G_{13}–G_{17}\}$—the appropriate indicators and goals:

Social Wellbeing $\{G_g\}$, g = 1–6, $|\{W_i\}| = 49$

- Goal 1. End poverty in all its forms everywhere
- Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
- Goal 3. Ensure healthy lives and promote well-being for all at all ages
- Goal 4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
- Goal 5. Achieve gender equality and empower all women and girls
- Goal 6. Ensure availability and sustainable management of water and sanitation for all

Economic Efficiency $\{G_g\}$, g = 7–12, $|\{E_i\}| = 27$

- Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all

- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 10. Reduce inequality within and among countries
- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
- Goal 12. Ensure sustainable consumption and production patterns

Ecological Safety $\{G_g\}$, $g = 13–17$, $|\{S_i\}| = 24$

- Goal 13. Take urgent action to combat climate change and its impacts
- Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Based at this approach a lot of questionnaires with the growing "quality" of the decision rule ($\sigma^2 \sim 1/P$) could be provided to assess the sustainability competence probability. And ASCP is the multiplication of KW(P), KE(P), KS(P), being the experimental assessment of probabilities for right allocation of the independent issues for Wellbeing, Efficiency, and Safety SDGs.

4 Results

4.1 Example 1: Students' Sustainability Competence Assessment

Over the past decade, the OECD Programme for International Student Assessment (PISA) has become the world's premier yardstick for evaluating the quality, equity and efficiency of the youth education at the level of school systems. PISA recommends governments and educators to identify effective policies that they can then adapt to their local contexts. The ambitious goals for the sustainable future of the global community seek to ensure that "all learners acquire the competence needed to promote sustainable development" (MFSDG 2015). Also, it is seen that questionnaire tests can serve as powerful incentives for students to put greater effort into learning, particularly if the tests have direct consequences for students. For teachers, the standardized assessments provide a way to compare instructional objectives against the results achieved, and to compare the performance of their students to the performance of students elsewhere in the school system, so that teachers can tailor pedagogy accordingly. At the school level, achievement data can be used to determine how resources and additional support are allocated; they may also trigger intervention by higher authorities. Achievement data can also be used to inform the design of education policies, to create more efficient learning environments and to prompt schools, teachers and students themselves to work towards centrally established education outcomes, to provide the innovative curricula design. Assessments can be used also to take stock of students' performance in order to make decisions about future instruction or to summarize performance for information purposes (Kankkunen et al. 2013). To follow the noted tasks, the designed questionnaire instrumentation has provided the experiments for identification of the respondents' competence at sustainability theme.

The first part of our findings is concerned on implementation of the experiments based at "Knowledge", "Attitude", and "Behavior" items. The experiments have been provided with three groups of respondents: group_1—high school students of 15–16 years old; group_2—high school students of 16–17 years old; and group_3—university students 19–20 years old. Group_3 has been tested before training (a priori), and it has been tested after (a posteriori) the appropriate training (72-h course, devoted to discussions of "strategic perspectives, and the connections between them for sustainable development"). For the groups #1, 2, and 3 (a priori) before testing it was provided "short introduction" about the experiment's targets, and briefs on sustainable development. Experiment arrangement: questions are represented by text (electronic screen) and by voice; written made answers (T/F) at the prepared tables via the intensive mode (questionnaire decision is provided during reading the item). Further, we strongly emphasized at this stage that students' responses would remain totally confidential. The experiment for group_3 (a posteriori) has been provided via internet and was not limited by time for decisions. The issued results are as the following:

- Group_1 (R = 40 respondents): The assessment of SCP, averaged by the respondents of this group (<ASCP>), <ASCP1> = 0.28 ± 0.03
- Group_2 (R = 63): <ASCP2> = 0.38 ± 0.03
- Group_3 (a priori, R = 32): <ASCP3_apr> = 0.42 ± 0.04
- Group_3 (a posteriori, R = 92): <ASCP3_aps> = 0.47 ± 0.02

In view of the lifelong learning it could be mentioned "Youth Sustainability Competence, YSCP". For practicing at high school it was suggested an initial assessment of YSCP (a priori), while after the undertaken training courses, as it has been seen at our experiments, the resulting YSCP (a posteriori) is increased meaningfully.

The second part of our findings, based at Ergodynamics, is about the applications of "transformation theory of learning" for adequate interpreting of the provided assessments. Here is undertaken the model look at the cognitive strategies, which ones are applicable to many kinds of human creativity. It has been seen that the MKAB procedure is not more difficult against of 45 dichotomy decisions (15 + 15 + 15). The last one is desired during the linear ordering of 10 alternatives, because 10!/2!(10 − 2)! = 45 (i.e., the number of combinations from 10 by 2). The undertaken version of MKAB is less psychologically difficult because it could be compatible with the individual operative memory (as a rule is about of 9 alternatives and PCU = 9!/2!/7! = 36—"Psychological Complexity Unit"), and so, the intensive mode questionnaire has been used (on-line). In turn, the complexity of MFSDG procedure is much more against the complexity of MKAB procedure. So, MFSDG procedure must be used by mode that it is controlled by "test-term", when additional information input is restricted between work-terms, being each under the intensive mode questionnaire. It was reviewed multi-stages assessment procedure. At the first stage it was selected NW, NS, NE—items from the indicator groups {W}, {S} and {E} respectively (there are a lot of such options as number of combinations from 49 by NW, 24 by NS, 27 by NE, and the last one is the other useful advantage of the designed procedure), and assessment of SCP(i, r) for r-respondent at the i-stage is:

$$\mathrm{ASCP(i, r) = KW(i, r) * KS(i, r) * KE(i, r)}, \text{ and}$$

$$\mathrm{KW(i, r)} = \frac{\mathrm{RW(i, r)}}{\mathrm{NW}}, \mathrm{KS(i, r)} = \frac{\mathrm{RS(i, r)}}{\mathrm{NS}}, \mathrm{KE(i, r)} = \frac{\mathrm{RE(i, r)}}{\mathrm{NE}}$$

At the next stages the previous procedure is repeated LW = P/NW, LS = P/NS and LE = P/NE times respectively with the new items' sets at each stage. And the final assessment of SCP is:

$$\mathrm{ASCP(r, P) = KW(r, P) * KS(r, P) * KE(r, P)}, \text{ and}$$

$$\mathrm{KW(r, P)} = \sum_{i=1}^{LW} \frac{\mathrm{KW(i, r)}}{\mathrm{LW}}, \mathrm{KS(r, P)} = \sum_{i=1}^{LS} \frac{\mathrm{KS(i, r)}}{\mathrm{LS}}, \mathrm{KE(r, P)} = \sum_{i=1}^{LE} \frac{\mathrm{KE(i, r)}}{\mathrm{LE}}$$

Here are used not "real" independent experiments because some items have been repeated. But based at "Zeigarnik-Effect" (Zeigarnik 1927) it could be provided the following reliability conditions:

$$\frac{\Delta \mathrm{B}}{\mathrm{B}} > \varepsilon; \frac{\mathrm{I}}{\mathrm{B}} > z$$

Here are used: number of psychological blocks B = (NW * LW + NS * LS + NE * LE)/PCU; ΔB = B − S; number of statistical blocks S = a_W * LW + a_S * LS + a_E * LE ($a_W + a_S + a_E = 1$); I—number of used GMI; ε, z—parameters of reliability. Having the desired parameter P—power of questionnaire, for parameters Ni, Li (i = W, S, E) and I, there are desired conditions:

$$\begin{cases} \Sigma Ni > PCU/(1-\varepsilon) \\ I > z * \Sigma(Ni * Li)/PCU \\ P \le \Sigma(Ni * Li)/3 \end{cases}$$

For example, if it will be used NW = 25, NS = 14, NE = 12, and LW = 14, LS = 25, LE = 29 (NW * LW ~ NS * LS ~ NE * LE ~ P = 350) and $\varepsilon = 0.1$, $z = 2.1$, so at this case the quality of the decision rule is measured by $\sigma_{SCP} \sim (0.75/P)^{0.5} < 0.047$. So, such assessment has the relative error of the order 10% (0.047/0.47) and is provided by the test-term of about 4 h.

The third part of our findings is based on the values have been seen through MKAB experiments. These ones explained the needs for the flow of sustainability information at any organization due to the lifelong learning that triggered the framework of life cycle thinking for sustainability of economy. Now we are ready to consider the leading idea provided by the "dissemination principle". While the quantities of ASCP(r) could be treated as the random variables (e.g., for group_3, a posteriori, we have for the experimental probability P{0.30 < ASCP < 0.63} = 0.68), the sustainability implementation mechanism is totally recognized if it has been adopted by the "main proportion" of the stakeholders being above some threshold level. The reviewed life cycle approach has identified the "threshold" $SCP_c = 0.47$, i.e., it is the rate, the cumulative competent vote above which provides the sustainability perspective. So, at our experiments it has been seen the "Rate of the respondents with the ASCP not less of the critical level, being of 0.47, RSCP", RSCP = 0.08, 0.29, and 0.38 respectively for the groups #1, 2, and 3 (a priori). In turn, for group_3 (a posteriori), we have found RSCP = 0.50. Of course, aimed for training, the feedback is assumed to continue the "work with mistakes" by small group collaborations.

The fourth part of our findings is summarized at Fig. 3, Tables 2 and 3, where the unified functional structure of the proposed questionnaire is represented. Here is the life cycle thinking triad for training Knowledge, Attitude, Behavior (and its transposition: Wellbeing, Efficiency, Safety). In business community the term "Triple Bottom Line" was coined to explain the importance of achieving sustainability, having three dimensions: Economic, Social, and Environmental. The procedure is implemented

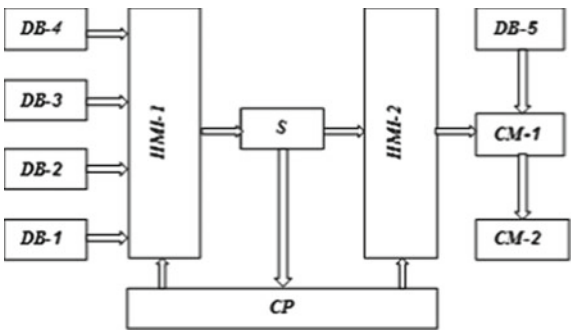

Fig. 3 Functional structure of the proposed questionnaire

Table 2 MKAB procedure

Module	Function	Notes
S	Respondents	Group of R members
DB-1	Knowledge items	15 items
DB-2	Attitude items	15 items
DB-3	Behavior items	15 items
DB-4	Strategic perspectives	15 principles
DB-5	Solutions matrix	Complexity: 45 dichotomy decisions
CM-1	ASCP computation	ASCP = (RW/|W|) * (RE/|E|) * (RS/|S|)
CM-2	RSCP computation	RSCP = |K|/R, K = {k: ASCP(k) > 0.47}
HMI-1	Input interface	Visual, voice, written
HMI-2	Output interface	{RW(r)}, {RE(r)}, {RS(r)}
CP	Control program	On-line

Table 3 MFSDG procedure

Module	Function	Notes
S	Respondents	Group of R members
DB-1	Wellbeing indicators	49 indicators
DB-2	Efficiency indicators	27 indicators
DB-3	Safety indicators	24 indicators
DB-4	Sustainability goals	17 goals
DB-5	Solutions matrix	Complexity: 16 * 3 * P dichotomy decisions
CM-1	ASCP computation	ASCP = KW * KE * KS
CM-2	RSCP computation	RSCP = |K|/R, K = {k: ASCP(k) > 0.47}
HMI-1	Input interface	Visual, voice, written
HMI-2	Output interface	{RW(r)}, {RE(r)}, {RS(r)}
CP	Control program	Test-term

by the functional elements—Data Base (DB-1, 2, 3, 4), as the sustainability principles and goals. Computation modules (CM-1, 2) are assumed for calculations of the ASCP quantities, in accordance to the defined allocations between questionnaire items and right solutions (DB-5—"solutions matrix"), and the quantities of RSCP, in accordance to the identified "threshold". Control program (CP) with the human-machine interfaces (HMI-1—input, HMI-2—output) are assumed to organize MKAB/MFSDG procedures by on-line/test-term mode.

4.2 Example 2: Companies' Sustainability Competence Assessment

A growing number of companies define inclusion in Dow Jones Sustainability Indices (DJSI) as a corporate goal. These companies publicly endorse their approach to addressing companies' sustainable and proactive key long-term opportunities. And, of course, such kind practices ultimately make them more attractive to investors. This activity creates vibrant competition among companies for index membership. The companies' sustainability profiles analyzing is known by using Corporate Sustainability Assessment (CSA) methodology, which is used as the basis for selecting companies for inclusion in DJSI (e.g., RobecoSAM practicing: www.robecosam.com). Each year, over 3,000 publicly traded companies, including 800 companies in emerging markets, are invited to participate in the CSA. All companies in the assessed universe are ranked in descending order by Total Sustainability Score (TSS) within their industries, which are derived from Global Industry Classification System (GICS). Eligible companies for DJSI are assigned to one of about 60 industries as defined by GICS. The composition of the DJSI is reviewed each year, based on the TSS. In TSS is used the industry-specific questionnaires feature between 80 and 120 questions focusing on economic, environmental and social factors that are relevant for the companies' success and are under-researched in conventional financial analysis. The CSA comprises an in-depth analysis of the world's largest companies based on economic, environmental and social criteria, such as corporate governance, labor practices and environmental policies, with a special focus on industry specific risks and opportunities companies face. Companies receive TSS between 0 and 100 and are ranked against other companies in their industry.

In this connection, the market conjuncture problem that has been reviewed by our approach is: "Developments for assessment of market companies' sustainability competence". The starting point is CSA based at financial materiality framework. The appropriate data are long-term economic, social and environmental factors having the most significant impact on a company's business value due which "being sustainable" is the principal question for DJSI ranking. A complete overview of the criteria for each of the 60 industries is provided by "Criteria Weights Document" (CSA Resource Center: www.robecosam.com/csa/resources) and is illustrated here:

Efficiency dimension

- Anti-crime Policy and Measures industry-specific
- Codes of Business Conduct general
- Corporate Governance general
- Customer Relationship Management industry-specific
- Financial Stability and Systemic Risk industry-specific
- Information Security and Cybersecurity industry-specific
- Innovation Management industry-specific
- Market Opportunities industry-specific
- Marketing Practices industry-specific
- Materiality general

- Product Quality and Recall Management industry-specific
- Risk and Crisis Management general
- Supply Chain Management industry-specific
- Tax Strategy industry-specific.

Safety dimension

- Biodiversity industry-specific
- Business Risks and Opportunities industry-specific
- Climate Strategy industry-specific
- Electricity Generation industry-specific
- Environmental Policy and Management Systems general
- Environmental Reporting general
- Operational Eco-Efficiency industry-specific
- Transmission and Distribution industry-specific
- Water-Related Risks industry-specific.

Wellbeing dimension

- Addressing Cost Burden industry-specific
- Controversial Issues, Dilemmas in Lending and Financing industry-specific
- Corporate Citizenship and Philanthropy general
- Financial Inclusion industry-specific
- Health Outcome Distribution industry-specific
- Human Capital Development general
- Labor Practices indicators and Human Rights general
- Occupational Health and Safety industry-specific
- Social Reporting general
- Stakeholder Engagement industry-specific
- Strategy to Improve Access to Drugs or Products industry-specific
- Talent Attraction and Retention general.

Within each criterion, it is represented evidence of a company's awareness of sustainability issues and for indications that it has implemented strategies to address them. Also, there are evaluated the company's progress in implementing such strategies as well as the quality of its reporting on these issues. Therefore, the questions within each criterion are structured to capture and evaluate the following elements:

- Awareness of the importance of these factors to its financial success;
- Determination of the potential financial impact (i.e. materiality) of its exposure to sustainability factors;
- Implementation of strategies to manage these sustainability risks or to capitalize on related opportunities in a manner that is consistent with its business models;
- Measurement of results in relation to stated Key Performance Indicators in order to evaluate the effectiveness of its sustainability strategy;
- Validation or external audit of stated results;
- Transparent communication of its corporate sustainability strategies and extent to which stated targets have been met.

The known questionnaire (RobecoSAM 2018) is designed to ensure objectivity by limiting qualitative answers and uses predefined multiple-choice questions in which each potential answer is assigned a number of points between 0 and 100. For the questions in which qualitative answers are allowed, the responses are evaluated using a predefined appraisal method, and convert the response into a quantitative score (companies must submit documentation to support the answers they have provided). Solution of the noted above Market Conjuncture Sustainability Problem (MCSP) is represented with data from this questionnaire by the design, based at SCP conception. Here is used the following model:

$$\max_{Q} \text{ SCP}, \quad \text{while} \;\; T = w * Q_W + s * Q_S + e * Q_E, \;\; w + s + e = 1$$

Solution of this task has the form: SCP = F(T, w, s, e). If there is "threshold SCP_c", then there is "threshold T_c": $T_c = T(SCP_c, w, s, e,)$. In accordance to (RobecoSAM 2018) TSS = 100 * T. If TSS < TSS_c (= 100 * T_c), then F(T, w, s, e) < F(T_c, w, s, e), and so SCP below threshold SCP_c is guaranteed by TSS below threshold TSS_c. We have (Fig. 4) $Q_E = 0.66$; $Q_S = 0.68$; $Q_W = 0.64$ and TSS = 66 (e = s = w = 1/3). At this case SCP = $Q_E * Q_S * Q_W = 0.29 < 0.47$. In adds, we have (Fig. 5) for BANKS: e = 0.43, s = 0.23, w = 0.34 and $T_c = 0.75$; ELECTRIC: e = 0.31, s = 0.40, w = 0.29 and $T_c = 0.77$; PHARMA: e = 0.48, s = 0.09, w = 0.43 and $T_c = 0.71$.

Now the noted market problem MCSP could be resolved by the following way. Together with the data for SAM Rank (SAM ESG Data Rating and Benchmarking: https://yearbook.robecosam.com our results confirm that having TSS below some threshold level, the company is assessed by SCP below the sustainability rate. The procedure is applicable, e.g., for Rating Agencies and Stock-Exchanges practicing. For example, one can see from the market data that currently (i.e., September 2019)

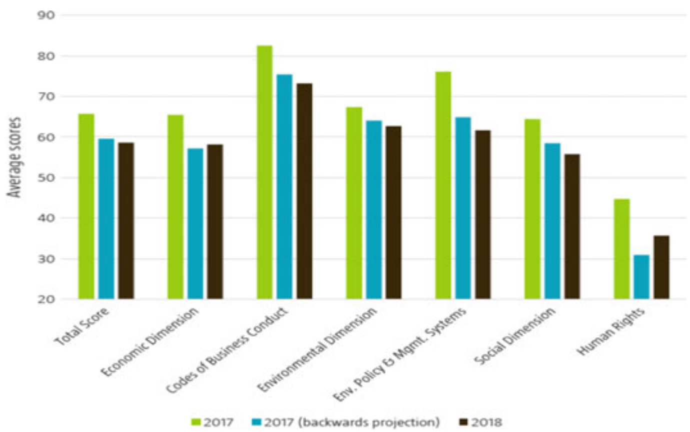

Fig. 4 Example of average score effects

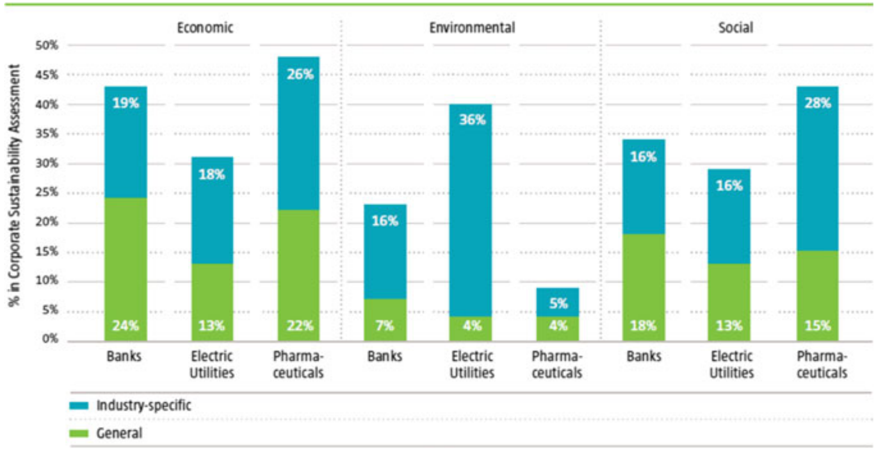

Fig. 5 General versus industry-specific weights by dimension

there are publicly listed companies assessed by TSS below the threshold rate (TSS_c), and so are non-sustainable in view of the realized condition $SCP < SCP_c$.

5 Conclusion and Recommendations for Further Developments

5.1 Current Vision at Lifelong Learning for Sustainability

Among the Global Challenges of 21st century the information complexity that we need to attain the sustainability targets looks as the corner milestone. Indeed, the volume of engineering information for the sustainability tasks, so named the verbal part, increases in linear proportion to the problem's complexity. And the information volume being in adequate relation to the task increases by exponent of the problem's complexity. The difference is growing quickly by the complexity and becoming even much above of the engineering part in practice, and it is out of the verbal professional activity because is managed only at the level of the individual intuition. And the last one is very often closely connected with the competence basis (Hilbert 2012, Schneider 2018).

From the above noted we see that the "volume" of knowledge for learning continues to increase, yet so do pollution, exhaustion of resources, and the dangers of ecological catastrophe. While the increased volume of learning should be a savior, it seems that we need a different kind of education—an education that takes us into the depth of things. Sustainability issues demand for specific kind of learning. Some authors (Kankkunen et al. 2016) call for a deep change in society to achieve more sustainability. Sustainability Competence ("SC") is not just a matter of acquiring some extra knowledge-based ability to perform relevant roles or tasks to the required standard. Attitudes are also important, and moreover, it is often necessary to change social structures. Change in attitudes takes time and needs a place for observation and reflection on how attitudes influence our behavior and acceptance of ideas. Indeed, in SC, it is difficult to identify what needs to be solved, and it is also not clear how to solve the problems that have been identified. Currently there is no consensus at the underlying question of "What is structuring knowledge in SC?" The undertaken efforts address the key challenges associated with knowledge structuring in SC, identify the requirements for the structuring of knowledge, propose reference models, and develop an ontology-based mapping tool as a solution-approach. Now we see that the nature of sustainability requires a fundamental change of epistemology, and therefore, of education. It has been seen that SC could be gateway to a different view of curriculum, pedagogy, organizational change, policy and particularly of ethos. At the same time, the effect of patterns of non-sustainability on our current and future prospects is so pressing that the response of the education system, i.e., lifelong learning, should not be predicated only on the "integration of sustainability" into teaching, because this invites a limited, adaptive response. We need to see the relationship the other way around, that is, the necessary transformation of training efforts towards the integrative and holistic approach implied by a systemic view of sustainability in education and society. The sustainability implementation now is seen through the life cycle management due to the collaborative decisions towards joining the sustainability knowledge of individuals that triggered the framework of life cycle thinking for any business activity (Voronov and Zinchik 2017; Voronov and Gridneva 2013).

Followed by such ideas, the undertaken life cycle thinking approach provides us with a well-based qualitative and quantitative outlook at "Generation for Sustainability" and "Innovations Dissemination" (Voronov 2019). During our modelling and experiments it has been tested the training activity comprised of the individuals' interaction and supported by a system of decision making in small groups, combined with the specialized assessment methods. The last one could be the adequate avenue to open new horizons of embedding of lifelong learning into practicing of sustainability competence. In view of the continuous education the youth sustainability competence probability, provided by the students at high schools, is mentioned as the initial base for higher education towards the Generation for Sustainability, being the part of lifelong learning system. Also, it was introduced the assessment for the rate of the respondents with the ASCP not less of the critical level (RSCP). RSCP data could be mentioned as the determinate for every finite social group and business structure (e.g., class, school, department, management team, stock-exchange, bank, industry branch, etc.). Particularly, the innovation dissemination could be realized through the decision rules based at the principle "competence of majority". At such way the management towards the sustainability could be realized by RSCP > 0.5 (the other option: "voting" practice could be desired at RSCP $> 2/3$). Our approach, combined of "Life Cycle Thinking" conception and empirical data "Sustainability Competence Probability" with the threshold model for product life cycle sustainability provides reasonable solutions, well agreed with the known innovation phenomena.

5.2 Research Prospects

Life cycle thinking approach is used also to analyze the value chain specified for transforming the human resources matched with the problems of sustainability. The undertaken approach introduces the rational heuristic form by which LCT is evolved into sustainability efforts with interdisciplinarity in the field of economic, environmental, and social aspects, and converged to a framework for Life Cycle Sustainability Assessment. As it is mentioned at life cycle thinking, "product" is comprised of "goods", "technologies", and "services". Here we w'd like to stress the technology component, where the word "technology" comes from two Greek words, translated as "techne" and "logos". Techne means art, skill, craft, or the way, manner, or means by which a thing is gained. Logos means word, the utterance by which inward thought is expressed, a saying, or an expression. So, this component could be used to represent "human factors" and is realized by two forms of knowledge—verbal and intuitive. There are several models of "knowledge", among which that one, based at the partial-order relations, provides good quantitative measure for it. Below the human factors are associated with "market of specialists", when we are interested for the new challenges at the labor market and knowledge basis of competence is carried by a person (e.g., graduated specialist), and the other option is about "market of innovations", where competences of know-how, patents, etc. in the form of verbal knowledge, after some owners, are traded.

Having in mind the concept of life cycle thinking, now we can provide reviewing the activity of lifelong learning for SD towards the objective of helping people to learn how to make informed decisions for the benefit of themselves and others, now and in the future, and to act upon these decisions. The following could be expressed with a notation "Lifelong learning for SD" = helping people to learn how to make informed decisions for Sustainable Development (as it is modeled above) and to act upon these decisions. So, there is the following definition: "Generation for Sustainability, GfS" is the functional system with the objective of helping youth to contribute to informed decisions for sustainable development, and to act upon these decisions. With this proposed definition in mind, it is important to point out the key definitions: "Generation" = "being generated" and "all persons born about the same time"; and "Youth" = "being young"; and "the period between childhood and maturity, the vigor or lack of experience, etc. characteristic of this". So, in accordance with the life cycle concept, the following elements of the educational system could be introduced:

- Primary School: nurturing interests;
- High School: comprehensive basics;
- Higher Education: graduating specialists;

- Integrated Product Life Cycle: specialists' contribution to informed decisions for sustainable development and acting upon these decisions.

Now GfS is achieved within a specific value chain, including the Primary School (PS), High School (HS), Higher Education (HE) aimed towards Integrated Product Life Cycle (IPLC). In terms of lifelong learning (i.e. educational continuum PS&HS&HE&IPLC) the qualitive phenomena at PLC will be evaluated by graduated specialists. And within the practice of the lifelong learning, "HE" stage is not a finishing point, but is a part of the path. One can see that after "HE" the graduated specialists do not finish their training but continue learning at activities of life cycle chain by acquiring competence during labor activity supposed to contribute to informed decisions for sustainable development and acting upon these decisions. Followed from this approach, the model is completed by its cost and utility functions, i.e., respectively $CE^{\nu}(\alpha; X^{\nu})$—for ν-"education program" (EP^{ν}, i.e., EP^{ν} = PS&HS&HE) towards some specialization "α", and $CA^{\mu}(\alpha; Y^{\mu})$—for μ-activity at "integrated product life cycle", competing for α-type of graduated specialists, and a quantitative measure for it is provided by "number" or/and "value" in accordance with knowledge concept, reviewed above. For example, a practical way shows the model for CE in the form $CE(X) = CE_{PS}(X_{PS}) + CE_{HS}(X_{HS}) + CE_{HE}(X_{HE})$, with material relations for "human factors, X", answering some qualification value-standard: $a * X_{PS} = X_{HS}$, $b * X_{HS} = X_{HE}$, and X (as column) $= (X_1, \ldots, X_r, \ldots, X_n)^*$ with r-value gradation. As relating the model for CA, our assumption is that the financing from the production part of PLC into the education programs should be the basic rule. So, we can put this in the form:

$$\left(Y^{\mu}, \partial_Y CA^{\mu}(\alpha; Y^{\mu})\right) = F^{\mu}\left(\alpha; Y^{\mu}\right)$$

F^{μ}– financing by μ-production activity with the cost, being one of $\{CM^i$, or CP^j, or $CT^l\}^{\alpha}$, while $\{C\}^{\alpha}$ are those costs, where α-specialists are engaged.

Having specifications for the sets of production factors at IPLC (e.g., capital funds at the production side, etc., $\{\tau p\} = TP$) and transformation of human factors into production factors, $\tau p = \tau p(Y)$, the sustainability problems of lifelong learning system now can be tested. Particularly, the dynamic model for sustainable development can shift in the direction of competitive equilibrium under the appropriate convergence conditions, closely related to the concavity of the social and environmental risk functions. The sustainable equilibrium at the market of graduated specialists could be provided by CE^{ν} and CA^{μ}, having $\partial CA^{\mu}(0) = \partial F^{\mu}(0)$ and $\partial^2 CA^{\mu}(0) = (1/2)\partial^2 F^{\mu}(0) < 0$, with "A" condition, reduced to:

$$\Sigma\left(Y^{\mu}, \partial_Y F^{\mu}(\alpha; 0)\right) - \Sigma\left(X^{\nu}, \partial_X CE^{\nu}(\alpha; 0)\right) > 0 \,\&\, \Sigma Y^{\mu} = \Sigma X^{\nu}$$

These relations provide a number of options to investigate some important problems of lifelong learning system. Particularly, the noted inequality could be weakened concerning TP-parameters due the financing the education program, in adds, by consumption activities.

At the next step, if we replace in our model the "educational institutions" by the "research and development institutions", the instrumentation for market of innovations could be provided Particularly, one can find the indicators for innovation efficiency by relation:

$$\mathrm{IQ(Y)} = \partial_{\mathrm{Y}}\mathrm{Q(TP)}$$

Here are used: TP—set of production factors, as it was mentioned before, and Q(TP) ∈ MP, MP—set of market parameters (e.g., profit at the production side of IPLC, etc.). And, for example, it could be stressed the extreme innovation efficiency of "knowledge" investment to the small and median size business activities.

In adds, the fundamentals at social evolution assume the line of Technological Stages, which go by the time-term period of about 40–60 years, known as "Kondratiev's cycles, K-waves", "Technological waves" and "Schumpeter's innovation waves" (Kondratiev 1928), (Schumpeter 1939). Due the triad-line "Technology—Industry—Economy" the social progress takes its development through exchange between stable phases, being the sustainable equilibrium, and non-equilibrium phases, being the source of the new order at the markets, desired for the new sustainability competence.

To understand how we can influence this giant shift towards a more sustainable path, it is useful to consider the role of technology and innovation as it interacts with human institutions and the market on a historical scale. So, J. Schumpeter took Kondratiev's work a step further, linking his long wave business cycles to technological innovation. He noted that each wave was linked to a profoundly influential and disruptive new technology and argued that these waves were determined by revolutionary technological innovation, and that they didn't occur by accident. Each of these waves were accompanied by simply incredible disruption to society, markets and institutions. Looking at riding the sixth K-wave effectively will require for competence of both anticipation and adaptation. Diffusion of both technology and societal learning will largely determine the competitiveness of individual countries and regions. Some scholars measure the diffusion process of new technology as taking upwards of fifty years, even in leading countries. This was true for the internet, for mobile technology, and even railroads. Of course, the societies also had to learn new behaviors and values to interact with these new technologies. Sustainability practitioners can accelerate the adoption of helpful technologies, as well as encourage the removal of problematic institutional barriers. This will, as always, require the ability to engage with and work productively with a wide variety of experts and stakeholders, having high level of sustainability competence.

The represented modelling is strong adjusted to the above reviewed ideas. So, let's introduce the rate of sustainability competence for an economy RPC(t), growing in the time-term of the technological stage (Voronov and Zinchik 2017):

$$\mathrm{RPC(t)} = \left(\frac{1}{\mathrm{T}}\right) \sum_{\mathrm{l=t-T+1}}^{\mathrm{l=t}} \sum_{\mathrm{i=1}}^{\mathrm{i=I}} \mathrm{g_i} * \mathrm{RGC_i(l)},\ \mathrm{t} \geq \mathrm{T}$$

Here is used: “T”—generation period, being as average time-term for individual labor activity (e.g., $T = 65 - 25 = 40$ years), and RGC_i, being a model for sustainability competence of i-business activity with g_i—weight:

$$RGC_i(l) = \frac{C_i\left(1 - q_i^{l*b_i}\right)}{1 + a_i * q_i^{l*b_i}}$$

Here is used: $0 < C_i \leq 1$—rate of sustainability competence; $q_i = \exp(-1/\tau_i)$, $b_i = 1 + a_i$, $a_i = \sigma^*\tau_i$, σ—“diffusion” coefficient at communicative processes, τ_i—“time-scale” for dynamics of innovation (which is assumed below as: $\tau_i = \tau$, as well as $C_i = C$). Based at the represented approach, we can determine the time-point (t_S) for sustainability access during the new technological stage by the relation:

$$SCP_c = RPC(t_S)$$

Particularly, for relatively low intensity of communicative processes $\sigma \sim 0$ (worst practice) and $C = 1$ (best practice) we have found:

$$t_s = \tau \cong 52\text{years}$$

And sustainability competence of business at each new technological stage is growing within 0.22–0.63 before the sustainable mode of economy will be accessed. The other features, being important to forecast and manage the dynamics of the coming technological stage, are the following:

$$\partial_\sigma t_s < 0 \, and \, \partial_C t_s < 0$$

In adds, the non-equilibrium phase could be treated as a source of a new order. Also, it could be supposed, based at the “physics” of the strength P(p) (refer: Fig. 1), and the average cluster size S(p) (refer: Fig. 2), for the largest cluster size, G, we have:

$$G(p) = \begin{cases} \sim L^2 : p > p_c \\ \sim L^{1.896}, sustainable\, branch; \sim S(p), other : p_n < p < p_c \\ \sim 1 : p < p_n \end{cases}$$

So, having growing “p”, at the point p_c the sustainability mode begins, which one lasts as long as “p” at the point p_n becomes relaxed to the non-equilibrium phase, and the dynamics is repeated once more again along the hysteresis curve G(p). The represented features of sustainability dynamics, based at our modelling, are well agreed with the known phenomena of K-waves and seem to be good basis for validation of the undertaken LC simulation and sustainability implementation mechanism via human factors, when the sustainability competence is adopted by the major part of the stakeholders being above some threshold level.

5.3 Life Cycle Thinking Practicing

Focusing on the market modelling for lifelong learning system by the way described above is very timely. Currently many countries are facing questions of relating the models that are most suitable for handling the increasingly complex and dynamic nature of education systems. There is need to provide education efficiently and contribute to equity, economic growth and innovation, being responsive to the demands of youth and business. Many governments have tested elements of the market approach as part of their answer to the above noted questions. There is increasing evidence of the market impact on the outcomes of educational systems, but that evidence as of yet is fragmented and often inconclusive. At the same time, the policy debate about market mechanisms in education is very strong. Proponents claim that education markets would provide higher quality, more efficiency and more demand sensitivity, whereas opponents stress the danger of schools with increasingly unequal quality, unequal access to high quality schools and, as a consequence, segregation. It is clear that in view of human rights the dimensions of "production" (concerning CE cost) and "consumption" (concerning CA utility) are tightly interlinked. This inter-linkage occurs in both directions. The educational programs seem to boost sustainability competence, and utilization activities are looking to provide the economic opportunities. The last ones, in turn, is used to improve the quality of educational systems. It is true, if market driving forces are combined with social and environmental objectives. While supply and demand are interconnected, it is still common practice to look at production and consumption from different sides. There are enterprise-oriented ("corporate social responsibility") and product-oriented ("product life cycle management") points of view. They could be addressed with private and public interests' analysis, supply and demand responsibility analysis. The other problems, e.g., similarly to unsustainable market trends in modern society, could be also addressed with the undertaken modelling (speculation challenge analysis, stability option analysis, etc.) (Voronov 2012).

As it is noted by education community, technological knowledge as a program of education for sustainability has a normative component that scientific knowledge lacks. Therefore, students of technology education need to learn that standards and other normatively determined types of technological knowledge. In this vein, relating to the life cycle concept, curriculum designers have regarded standardization as a component of different levels of technological education. There it still remains the problem of how to put those standardization education policies into practice. Furthermore, there is the problem how to develop and implement hierarchically structured and functionally unified standardization education programs from primary to post-formal education. In our model, the "program approach" is used, following the life cycle approach. So, having the product as goods, services and technologies one can find the following training programs: (1) resources, (2) production, (3) consumption, (4) utilization, and (5) resources' market, (6). products' market, (7). wastes' market. There are not many practices at primary and secondary education level in the area of program education. Higher education programs assign highest priority to standardization. Many standardization organizations in "old" industrialized countries have for decades provided various post-formal education programs to meet the demands of industry in the form of "project management", well based at product life cycle concept. Countries which were industrialized more recently are currently taking up similar activities, and some developing countries are becoming more active in this field.

The practical activity based on our modelling, is manifested by the entrepreneurial approach, i.e. the activity of organizing and managing a commercial undertaking that involves markets of specialists and innovations, environmental and social risks. The following priorities can be identified:

- Promotion of economic development is the key objective of the entrepreneurial approach, and typical actions such as subcontracting, production cooperation, joining forces in marketing, transfer of technologies; preconditions for further investments in production and infrastructure projects; mechanisms of simplifying international trade; sustainable management practices; developing mutual business integration; promoting the attractiveness of the regions for investments; creating innovative ICT support for markets and education; promoting research and technology development, education, and training in business cooperation; developing an environmentally sound tourist industry; promoting business start-up;
- Maintaining and improving the quality of the environment and increasing the attractiveness of the participating regions (common challenges) and typical actions such as using at the field of natural resources and implementing sustainable management systems; promoting nature protection and conservation; promoting research, planning, and education in the field of complex sustainable development; supporting public awareness of sustainable development; improving municipal systems of waste management; developing environmentally and socially sound technologies; promoting cooperation to reduce environmental and social risks;
- Opportunity to strengthen "people-to-people and civil society contacts" at regional and local levels (social development and civil society) and typical actions such as the promotion of a healthy (i.e. sustainable) lifestyle; mutual research on social adaptation; health protection within the educational sector; promotion of innovative information exchange; improvement of medical services.

By adopting the sustainability methodology, it could be capable to increase the mass rate of sustainability competence along any product life cycle in economy. The appropriate lifelong learning procedures could be interpreted like the approach to the global inertial mechanism of sustainable development. The undertaken models, experiments, calculations, and the unified functional structure of the proposed questionnaire, have shown the examples of productive path for cooperation between education institutions as well as research and development institutions with business to promote the sustainability progress by the lifelong learning. And the introduced examples confirm the road map to move the ideas of sustainability competence to the reality by the enhanced lifelong learning system based at life cycle thinking.

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Rethinking Human/Nature Ontology in the EFL Classroom as a Focus of Education for Sustainable Development

Jackson Ver Steeg Jr.

Abstract English as foreign language (EFL) curricula commonly include only limited exposure to sustainable development (SD) topics. Because SD is a global issue and participation in that conversation is dominated by English, students in the EFL classroom can greatly benefit from an increased exposure to an SD lexicon and SD topics. While traditional education for sustainable development (ESD) focuses on student awareness of issues and behaviors, psychology practitioners suggest that additional gains in ESD may be achieved by focusing on human ontology of and their relationships to Nature. Accordingly, this study examines ways of introducing inner work and intersubjectivity into the EFL classroom with the goal of examining and altering student viewpoints regarding Nature. Suggested classroom modifications are presented, including content and text, as well as course strategies. Justifications are presented for including mindfulness and intersubjectivity in exercises in the EFL classroom as a method to practice ESD.

Keywords Intersubjectivity · Education for sustainable development · Instructional design · Ecopsychology · Worldview · Nature ontology · ESD · EFL · SD

1 Introduction

The October 2018 reports from both the United Nations' Intergovernmental Panel on Climate Change and the World Wildlife Federation (WWF) contain dire warnings of the need to protect our environment and pursue sustainable practices and suggest that time is of the essence. The former reports that we may have a little as 12 years to cut industrial emissions by 45%, while the latter presents studies that show a wildlife population loss of on average 60% over the last 40 years. Further, WWF UK

J. Ver Steeg Jr. (✉)
Wenzao Ursuline University of Languages, Kaohsiung, Taiwan
e-mail: jacksonversteeg@gmail.com

International Graduate Program of Education and Human Development, National Sun Yat-sen University, Kaohsiung, Taiwan

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Chief Executive Tanya Steele notes that "we are the first generation to know we are destroying our planet and the last one that can do anything about it" (Picheta 2018). That report also quoted researchers who estimate that, by 2050, there may be more plastic in the ocean than fish.

If these reports are credible, something is very, very wrong. Education for sustainable development (ESD) is an attempt to empower today's students with abilities and responsibility for creating a sustainable future, not only in terms of these critical issues of environmental degradation and climate change, but also economic and social issues such as poverty and gender inequality. Although there is no one specific definition for ESD, a well-considered one would be expressed similarly to this definition from UNESCO Bangkok, which defines ESD as:

> a learning process (or approach to teaching) based on the ideals and principles that underlie sustainability and is concerned with all levels and types of learning to provide quality education and foster sustainable human development—learning to know, learning to be, learning to live together, learning to do and learning to transform oneself and society. (UNESCO, Definition of ESD n.d.)

Campus initiatives at all levels have addressed the need for the introduction of sustainable development (SD) issues into curricula. One place where SD issues are generally addressed more haphazardly, rather than through a dedicated ESD curriculum, is in the English language classroom, which, understandably, tends to be primarily driven by language teaching issues and pays only passing attention to SD issues when they are part of a language curriculum in the form of a chapter or two of an English textbook.

The global conversation about SD issues, however, is a continuing dialog that is guided not only by scientific research but also by language, with its communicative potential and transformative ability. This conversation, though, seems to be governed by a few major languages—English, French, and Spanish. The former two by virtue of intergovernmental organizations such as the U.N., and the latter by virtue of the fact that many sustainability issues considered to be of greatest concern by Western organizations occur in Central and South America. For students whose native language is other than those, they may be fortunate enough to encounter SD ideas in great detail in their native language and develop complex opinions and inspired ideas. In order to express those ideas on a global stage, however, an ability to do so in one of the languages governing the conversation would be instrumental, and could have a profound effect on the ability to improve sustainability. The better we develop SD concepts, vocabulary, and ways of relating to other actors, the better equipped non-native English speakers will be to participate in global solutions.

2 Theoretical Background

In the university English as a foreign language (EFL) classroom, we may teach our students about our oceans, about recycling and energy choices, or about Fair Trade coffee. We may even actually affect student behavior in terms of sustainable choices. But is it enough? These recent reports suggest that much more is required—addressing not only actions, but addressing what we generally conceptualize as "ways of thinking." Current trends in ESD do indeed measure student attitudes towards sustainable development, in terms of their awareness of issues and their attitudes about such things as being a citizen of the world, feeling a responsibility to help those who need it, knowing their behavior can impact people in other countries, boycotting companies who have unsustainable practices, and having respect for people from other cultures (OECD 2018). These are all outward facing attempts to change the future, and as such are necessary for the type of change that is required.

A point I have argued in other work is that sustainable development (SD) is a topic that should not only be in every EFL classroom, but should be a stand-alone topic of English study. Our students are studying English, among other reasons, as a means to participate globally. Because SD is a global issue which requires global solutions, developing both an understanding of sustainable development topics and the ability to use an English lexicon which permeates discussion of those topics allows students to inject their voices into the argument and help define the future.

But for our students—attached to their cellphones, facing a barrage of advertising with every waking hour—are these outward-facing postures of attitudinal and behavioral change, when combined with an English lexicon of SD, sufficient for the enactment of change? A method of engagement with SD by ecopsychologists has addressed the issue of the degradation of the natural environment by using ideas of inner crisis that are traditionally used therapeutically with individuals, and has extended those ideas toward the crisis affecting our natural environment. Work by Cohen, Bai, and Rabi has outlined an argument for sustainability education not as one requiring simply changes in behaviour, such as energy-saving, but instead as one where the change for sustainability must be driven by nothing less than a radical refiguring of our collective ontology such that we "disrupt the damaging habit of perceiving Earth…as a resource base for creating material wealth…and human[s] as 'tools'…to provide the labour for producing consumer goods" (Cohen, Bai and Rabi 2014, p. 24). Drawing from the psychology that is generally applied to individuals, Cohen et al. draw a thread starting with what they recognize as self-destructive behavior in society in general, which results in addictions meant to guard against psychological pain. To them, consumerism can be understood by Kaza's notion of this addiction as being meant to fill a lack in our collective society, as well as being an indicator of what they read as an attachment rupture in our collective psyche, as has been explained by Jordon (Cohen, Bai, and Rabi 2014, p. 25). Following the research on psychological therapy with regards to healing the wounds of such an attachment rupture, Cohen, Bai, and Rabi (2014) propose to create.

> relational environments in which afflicted individuals can experience intersubjectivity: that is, that is, the experience of both being heard, seen, listened to, received, and being energetically "held." Within such environments, opportunity to experience what has been profoundly lacking… will be possible. Warm and nurturing relational experience in a secure, safe, and trust-building relationship begins to re-build the missing ontological security and soothe humans who are experiencing existential anxiety. (Cohen, Bai, and Rabi 2014, p. 25)

They propose building this environment in classrooms to affect healing in students and guide changes in sustainability from an ontological perspective, and provide a few vignettes to exemplify how this would work in practice. While instructive, the vignettes seem somewhat out of place in an EFL classroom as they rely on concepts of meditation, healing and sharing rather than language instruction, and may not be embraced by students as within the realm of activities that develop English language ability. Nevertheless, I suggest that the work of ESD which addresses attitudinal rather than behavioral changes can find a home in the EFL classroom as well.

Numerous studies have found that altering one's relationship with Nature—to draw closer—has benefits in terms of increased personal happiness as well as increased interest in engaging with sustainable development issues. Such is the strength of Nature that connectedness with Nature alone has been shown to increase well-being (Zhang, Howell, and Iyer 2014). Schultz (2002) investigated the psychology of human–nature interaction at a very accessible level, and as such may be a beneficial inclusion in an upper level EFL class. Other investigators have developed means of quantifying this human nature interaction through the Connectedness to Nature Scale (Mayer and Frantz 2004) and the concept of Nature Relatedness (Nisbet, Zelenski, and Murphy 2009; Nisbet and Zelenski 2013). Other research (Howell, Dopko, Passmore, and Bruno 2011; Capaldi, Dobko, and Zelenski 2014) has also confirmed the value of mindfulness to well-being, and that increased mindfulness and connectedness, a cognitive structure, can result in increased pro-environmentalism, a behavioral structure (Barbaro and Pickett 2016).

Accordingly, a method to introduce the concept of intersubjectivity and its potential benefits into the EFL classroom is needed. This paper suggests ways to do that, as well as to promote the restoration of an "intrinsic value" to Nature, valuing it not for its utility, but for its existential right to exist (Bai and Scutt, 2009 p. 95). Below, some suggestions for the EFL classroom are presented, with justifications from within these ecopyschological models.

The question guiding this research is how to successfully introduce the concept of intersubjectivity into the EFL classroom through classroom activities and teaching strategies. I apply examples from my own EFL classrooms, with effective strategies identified by sampling student responses. In addition, I supplement these by identifying other texts and exercises that would likely be useful in a similar context. The greater purpose of this study is to disseminate learning activities designed to contribute to learning about intersubjectivity as a mode of education for sustainable development, and make classroom strategy recommendations for other instructors who wish to do the same.

These strategies and activities can used in classrooms composed of English students of different levels by assessing the appropriateness of each text or exercise, and modifying it where necessary to fit the student level. The texts and exercises below were used in several sections (~35–40 students each) of a four-skill general English program at a language university in southern Taiwan. Though students tested into the advanced level course, none were English majors, and were drawn from other language, communications, and business departments. The texts that were used served as supplemental texts to accompany the student textbook, which itself had a few units dealing with sustainability issues, but none dealing with the aspect of intersubjectivity.

3 Classroom Strategies

This section introduces pedagogical strategies that can be used in the classroom to help students develop the quality of intersubjectivity. We first examine texts that could serve as either a central part of a course or learning unit, or as supplemental learning material. Pre-designed learning units, accessed from Internet sources, are also introduced. Next, we examine activities that could be done in class to help promote intersubjectivity, as well as discussing writing activities specifically.

3.1 Primary Course Content

This section identifies both texts, primarily literary in nature, as well as Internet sources that can be used as primary or supplemental course materials.

3.1.1 Texts

In order to promote understanding of intersubjectivity in students and address the rupture in our collective psyche, emphasis should be placed on texts that introduce ideas of interconnectedness with people and with Nature, including those that detail failures in sustainability. It stands to reason that the texts chosen for a course can have a great effect on a student's inner belief system. Many texts and videos can be found at different levels. These include indigenous peoples' stories, Western mythology, children's literature, and stories from graded readers.

Children's Literature. Children's literature is rich with stories that address issues of sustainability, but ones that deal with issues of world views and promoting the voice of the marginalized are less commonly presented. Box 1 presents a list of children's literature texts that would be appropriate for use in the EFL classroom, and which promote ontologies of inclusiveness. In terms of texts that have the potential to successfully present in the EFL classroom a radical shift in ontological beliefs, many of these texts make the strongest and most enduring statements.

Box 1 Selected texts from children's literature featuring alternative ontologies Source: Adapted from Resources for Rethinking (http://resources4rethinking.ca/en/home).

A Journey Through the Circle of Life by Desiree Gillespie and Kimberly McKay-Fleming
A River Ran Wild by Lynne Cherry
A Salmon for Simon by Betty Waterton and Ann Blades
Blueback by Tim Winton
Claire and Her Grandfather by the Ministry of Northern Affairs Canada
My Sister Sif by Ruth Park
Nanabosho and the Butterflies by Joe McLellan, Matrine Therriault, and Jackie Traverse
Shi-shi-etko by Nicola I. Campbell and Kim LaFave
Smoke by Dawn Richardson
Solomon's Tree by Andrea Spalding and Janet Wilson
The Giving Tree: A Retelling of a Traditional Métis Story about Giving and Receiving by Leah M. Dorion
The Little Hummingbird by Michael Yahgulanaas
The Secret River by Marjorie Kinnan Rawlings and Leo Dillon
Walking the Boundaries by Jackie French
Wishtree by Katherine Applegate

Graded Readers. Another kind of text commonly used in the EFL classroom are graded readers, which are used most successfully in Extensive Reading programs. Texts are either abridged versions of classics or original stories and are scaled in difficulty to meet the levels of both very low and very high-level English learners. Notable in regard to introducing SD issues are Cambridge English Readers (scaled from 1 to 6), which are original stories and often address contemporary issues. Titles such as *Blood Diamonds* (level 1), *Within High Fences* (level 2), *Deadly Harvest* (level 6), and *Rabbit-Proof Fence* (Oxford Bookworms level 3) contain themes of development, migration, and biodiversity, and social justice. While these adequately fulfill needs to address SD themes, most do not deal with alternative worldviews except as a sub-theme. Certain texts, however, can function to give a voice to those who have suffered, which is a means to develop intersubjectivity. *Rabbit-Proof Fence* addresses the family separation of Australian aboriginals, while *Jojo's Story* (Cambridge level 2) details the tale of a child in a war-torn country. While there are currently not a great number of titles that perform such a function, certain graded readers are short enough and accessible enough to enable a class discussion that would allow an approach to intersubjectivity

Poetry. Another textual locale for discovering and discussing ways of thinking about the world around us is found in English language poetry and poetic prose, though its use may be limited to upper level students. Poetry can be used as a major or supplemental text to serve as a springboard for exploring issues of worldviews and of imagining our world of the future. Poets such as Robert Frost have, in numerous poems, concerned themselves with humans and the meaning that “places experienced” give to their lives. Robert Browning explores the connection between landscape and emotion in his two poems “Meeting at Night” and “Parting at Morning,” suggesting the ability of Nature to be an actor in a dialogue involving personal emotion.

Alfred, Lord Tennyson’s “The Eagle” provides a beautiful short vignette for students as an example of imaging the world from something else’s point of view. Such a poem might serve as a sort of model of the ability to change one’s viewpoint. The first tercet leads students to understand that Nature may be considered from afar as a thing of beauty, while still remaining as an object: “He clasps the crag with crooked hands;/Close to the sun in lonely lands,/Ring’d with the azure world, he stands.” As the eagle is observed from far below, it appears as an object high on a cliff, the blue sky forming a background for us, the viewers. In the second tercet, the eagle becomes an active subject in the poem, displaying the power of Nature. The point of view shifts to that of the eagle, and the words suggest the power of the eagle relative to that around it. “The wrinkled sea beneath him crawls;/He watches from his mountain walls,/And like a thunderbolt he falls.” Students at upper levels can consider Tennyson’s word choices and what connotations might be suggested by words such as crag, lonely lands, and stands. Questions might include: Who is watching the eagle? How is it close to the sun? How do you phrase like lonely lands make you feel about the eagle? Interpretation of the second tercet might include considering the point of view suggested by the wrinkled sea. To whom does it appear wrinkled? Which words exhibit power? Why is it his mountain? What does the eagle share with a thunderbolt? In addition to the value of this text in terms of its language and poetic interest, this text has also served in my EFL classes as a way to introduce the idea of considering a situation from the point of view of a non-human actor.

Students at upper levels can access Ralph Waldo Emerson’s “Self-Reliance,” which serves as a primer into self-reflection and ontological change. Henry David Thoreau’s *Walden* may also serve a similar function. Interestingly, a few children’s literature texts have developed transcendentalist thought, and would appeal to lower level students. The delightful *Henry Hikes to Fitchburg* and *Henry Builds a Cabin* by D.B. Johnson can easily serve as an introduction to transcendentalist concerns for even low-level English language students. In addition, the psychological dimensions of human-nature connections can be introduced to upper level college students by readings such as Schultz (2002).

3.1.2 Designed Learning Units

In addition to reconsidering texts only, instructors may want to take advantage of various pre-designed teaching units. There are a number of free web-based resource sites that address SD issues in general, but the pool of resources which address the healing work necessary for our collective psyche is comparatively shallow. This paper presents a sampling of designed learning units that may be adapted for use in the EFL classroom. The group Learning for a Sustainable Future collects' classroom plans to cover many different SD issues, from climate change to global inequalities, on a website called Resources for Rethinking (http://resources4rethinking.ca). While it is a wide-ranging and valuable resource, the appropriate exercises here are those that address the development of alternative worldviews, and bring intersubjectivity to the forefront.

Table 1 presents a list of learning units that address the development of alternative subjectivities, and which may be appropriate for use in the EFL classroom.

University-aged learners at lower English levels may find some of the exercises targeted at native-speaking elementary students to be conceptually too simple, so instructors should take care to choose a learning unit that is compatible with both English level and conceptual ability.

3.2 Class Activities

This section identifies classroom activities and teaching strategies that develop intersubjectivity and challenge student perceptions of worldview.

3.2.1 Warm-up Exercises

An easy method to build community or mindfulness is to use a warm-up exercise in the first 5-10 min of class through a group discussion intended to re-establish bonds between students. As noted above, in certain classroom situations, these exercises may seem appropriate by setting the tone for further learning. In the EFL classroom, however these exercises should be tied to increasing language learning and usage in order to be embraced by students. Guiding questions in an opening group discussion can be both simple and effective: How are things going this week? How was last weekend? What are you most worried about this week? What is your biggest challenge this week? Alternatively, opening exercises could focus on a mindfulness exercise. While many mindfulness exercises such as breathing exercises seem well out of the purview of the EFL classroom, ones that use writing can incorporate English language practice. A simple one to use is a reflective writing where students are asked to write in as much detail as possible for ten minutes on a series of simple questions, as "Be quiet and focus on the place around you. What do you hear? What do you see? What do you taste? What do you smell? and What do you feel?" After such a writing exercise, students may be better centered to engage with SD class work. Student comments regarding this exercise in class were overwhelmingly positive, and noted both a calming effect, and a challenge. After use in an upper level English class in a language university in Taiwan, student responses were overwhelmingly positive in nature, and included:

Table 1 Learning units that potentially aid in developing a different human/nature ontology

Learning unit title	Summary
Student level: elementary	
Maq and the Spirit of the Woods	Video from national film Board of Canada exploring interrelationships between Nature , humanity, and spirituality. (http://www.nfb.ca/film/maq_spirit_woods/)
First nations games	Introduces outdoor games played by First Nations children
Walking with the earth-Pimohtiwin	Introduces first nations ideologies of interconnectedness and ties them to a nature walk
Student level: elementary, middle	
Creating a three sisters garden	Teaches about interdependence and interconnectedness in plants and humans
Creation and unity of earth, the white buffalo calf woman and the sacred pipe	Uses aboriginal legends presented in the book as a base for learning activities taken from: Keepers of the earth: Native American stories and environmental activities for children
The Woolastoqewiyik	Explores the interdependency of humans and the Earth
Student level: mddle, secondary	
Inuit observations on climate change	Video presenting climate change from a more immediate perspective
Student level: secondary	
Towards a new perspective	Tied to David Suzuki's movie *Force of Nature* addressing the stewardship of the earth
Four directions teaching	Video presents knowledge and philosophy from a First Nations perspective
Journey into new worlds The matrix of life	Tied to David Suzuki's television series *The Sacred Balance* addressing the interconnectedness of life and spiritual world views
Tread lightly: learning from the past, defining our future	Explores the decline and failure of previous civilizations (http://resources.tiged.org/tread-lightly-learning-from-the-past-defining-our-future)
Yukon Kings	Video from Global Oneness Project detailing traditional ecological knowledge in salmon fishing (https://www.globalonenessproject.org/library/films/yukon-kings)
Student level: elementary, middle, secondary	
Cultivating peace in the 21st century	Module that promotes a culture of peace and understanding of others' values (http://www.cultivatingpeace.ca/main.html)

Source: Resources for rethinking (http://resources4rethinking.ca)

> "This made me calm down."

> "It is a very special exercise for me…I think it's a good way to release my stress these days."

> "Interesting. When I write down things, I feel I have more control of the situation…aware of everything around me and more organized."

> "It is good for me to have a brief time to slow down my mind, it is hard from the beginning."

A number of studies have found positive effects of mindfulness exercises, particularly in students aged 15-18 (Carsley, Khoury, and Heath, 2018). As this is the age range for high school/university EFL classes, this suggests that students may derive benefits from such exercises.

3.2.2 Group Work

The most effective classroom format to foment change in the collective psyche of society is to work collectively and use group work as an organizing structure. Much of a student's time in university is spent in performing tasks in isolation—taking tests, doing individual homework and completing writing assignments. These can be isolating and competitive, rather than seeking a collective interconnectedness. By utilizing group projects, group writing, and group homework, students can be immersed in the type of problem-solving necessary for sustainable development, as well as developing empathy and understanding, seeing their roles in larger projects, and forming a supportive inner learning community that encourages healing. Group activities can vary widely in their goals, processes, and outcomes, so not all group activities may be suitable for development of intersubjectivity and collective thinking, but likely successful formats would be group writing, group projects, and group discussion. Again, there is broad latitude as to what may be successful, so instructors should design group work such that other elements identified here can be incorporated into the EFL classroom.

3.2.3 Examination of Ideologies

One obvious area of exploration and criticism that can be used in the EFL classroom is modern materialistic life and consumption behaviors. Writing assignments, especially, can be useful in exploring the isolating effects of materialism and consumption, described by some as "an internalization of self-limiting and destructive patterns" (Illich 2000). As a counter to the insidious effects of the overwhelming influence of consumerism, students could be asked to consider the life cycle of a product of technology or produce, or analyze their own consumption practices and the emotions that accompany those practices. Another exercise encouraging reflection on the role of material worth may also to be a "no electricity/energy day" where students are asked to go without any energy-driven products for a period of time and write a reflective essay on the experience, focusing on the emotions and connections that they felt during the experiment. An alternative to this assignment may be a "no news" or "no social media week" to help students realign with more immediate and sensory experiences. Like group work, there is a great number of possible projects that can address inner work and help heal the "rupture" previously identified. Developing a successful project entails giving adequate discussion time before and after the project to situate the criticism of what is, for most students, a well-ingrained process of materialism.

3.2.4 Point of View/Worldview Exercises

Instructors should consider the inclusion of point-of-view/worldview exercises where students are asked to assume the position of one who approaches a particular SD issue from an alternative viewpoint or an exercise which investigates environmental justice and injustices. At the heart of this task is the development in students of what has been identified by some ecopsychologists as the need to break the culture-Nature, subject-object dichotomy which undergirds a dualistic consciousness in favor of experiencing an intersubjectivity which is "a sense of knowing the other as a 'fellow being' whose identity and welfare are bound up in some ways with one's own" (Bai and Scutt, 2009, p. 99). Instead of just talking about a migrant crisis, for example, instructors could develop exercises which ask students to imagine themselves in the situation and relate the emotions that they would feel in such a situation. This could take numerous forms, and is especially useful in writing exercises. Students could also address global inequalities from a different point of view, as in a writing assignment like "A Day in the Life of Robin Hood/The Good Samaritan: 2020." Drawing a point of view exercise toward Nature can be constructed as a group activity where student groups discuss and create an Animal/Ocean/Forest/or Desert Bill of Rights. In this exercise, students should consider what rights should be given to the ocean and what rights we as citizens should share with the ocean. Other writing and discussion exercises can direct to identifying exactly how a "fellow being"—whether it be human or Nature—has an identity bound with one's own.

Loren B. Byrne (2016a) has collected a number of classroom strategies and exercises that can engage students with sustainability issues in her volume Learner-Centered Teaching Activities for Environmental and Sustainability Studies, and among them are a few that are appropriate for developing intersubjectivity. Byrne (2016a, 2016b) details one such exercise designed for a native speaker audience which examines the concept of worldview, but which would work equally as well in an EFL context. Students, either individually or in groups, work to construct a fictional character through assigning him/her identity attributes such as age, hometown, religion, environmental ethic/attitude and political affiliation. These attributes can be modified as necessary for appropriateness. Students then discuss an environmental or sustainability issue through the lens of this constructed identity as an alternate worldview. In order to substantiate this idea of worldview, students are asked to wear a pair of glasses that they have brought with them, in order to "provide a concrete visualization of the abstract worldview concept." (2016a, 2016b, p. 48)

Students can be encouraged to trade glasses and describe the issue from a different worldview, followed by discussion.

A similar lesson from the same volume (Witt 2016) ask students to create biographies of hypothetical participants in a local environmental issue and craft a response. This exercise is likely more suitable for more advanced EFL classrooms, as the theoretical underpinning is that of environmental justice rather than worldview. Witt uses the United States Environmental Protection Agency (2015) definition of environmental justice, and there is much to unpack for the EFL classroom before its use: "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement or environmental laws, regulations, and policies." The focus of this exercise on demographic information, however, is a useful lesson in the EFL classroom, and could be used as support for other exercises featuring gender, race, and class.

A simpler investigation into environmental justice is presented by Darby (2016) and uses candy and environmental amenity/disamenity cards as a means to represent unequal resource allocation. Students are asked to perform the allocations on their own without any guidance from the instructor, and must reflect on the process. This type of exercise could be quite successfully modified for students of all ages and English abilities, as the visualizations and concretizations are well understood without language, and discussion would follow the natural level of the students.

3.3 Writing Assignments

This section introduces writing assignments and writing feedback mechanisms designed to invoke intersubjectivity.

3.3.1 Place-Based Writing Assignments

One particularly valuable type of assignment that offers the potential for students to begin to see their relationship with Nature differently is one that engages students in re-evaluating the importance of the places around us. While place-based writing can be used in analyzing either natural or synthetic spaces, by asking students to focus on a natural space, they can engage with intersubjectivity. One particularly useful exercise is a "place portrait" from Owens (2001), which asks students to consider a particularly meaningful natural space. I can use as an example my own meaningful natural space, that of the trail up Tenderfoot Mountain in Colorado that was a yearly pilgrimage for my family, and was where I learned the beauty of quaking aspen trees "ring'd with an azure world" and the silent awesomeness of elk bones bleached white, tucked under a bed of white pine needles. Student responses to the assignment in my EFL classes frequently identify its ability to develop a new way of thinking of Nature. Certainly, some students only engage in the descriptive element of the assignment rather than reaching for the significance of the place. Accordingly, peer revision or a one-on-one conference is important in guiding the student in reaching further with the writing.

3.3.2 Writing Assignments Incorporating Positive Peer Review

For better alignment with developing the ESD mode of intersubjectivity which allows voices of suffering to be heard, writing assignments in the EFL classroom should include an element of peer-review that includes both positive and negative feedback. In order to counter the sometimes-negative effects of traditional educational experiences that prioritize correction and conformation to writing conventions, writing assignments can be structured with a peer-review element where reviewers are asked to make both constructive critical comments as well as specifically positive comments. These take the form of complimenting writing ideas and descriptions. As simple as this is, students are generally accustomed to negative critical responses to their personal writing, and viewing positive responses to their own personal revelations may have encouraging and sometimes surprising effects. This type of exercise is an example of a therapeutic action that can validate their personal concerns and support the development of their inner life. Indeed, much anecdotal evidence from my writing classes suggests that students are genuinely pleased with positive feedback, and find that it supports not only their writing but also their development of positive opinions of their academic community.

3.4 Positive Feedback

Including positive feedback mechanisms in classes, both L1 and EFL, can greatly affect healing work and influence how students view themselves and how they relate to and act in the world. I can recall one exercise from my own primary school experience. We were instructed to write our names on the top of a piece of paper. The papers were then redistributed and circulated around the classroom, and we were asked to write one compliment for each fellow student when we received their paper. At the end of the exercise, the paper was returned to us with some 20-odd compliments. It was a monumental feeling to hold in my hand a catalog of positive feedback about myself, and it opened up a new universe of how I related to my world. This exercise remains a testament to the significance of breaking, even temporarily, from the traditional educational environment. A similar group exercise is described by Lougheed and Coholic (2018), called Handprints, where participants trace their handprint on a piece of paper then affix the paper to their own back. Participants then take turns writing positive affirmations on each other’s sheets of paper for about 15 minutes, allowing participants to share what they appreciated about others in the group while developing self-esteem and reflection (2018, p. 6). Interestingly, the Lougheed and Coholic study was not performed on a group of students, but instead with youth exiting foster care. An interview with a participant points out the fact this type of positive support is, not surprisingly, rarely provided in schools, either in L1 or L2 classrooms, saying “It was nice to have other people to talk to about that kind of stuff because you know at school you don’t just like talk about it with anyone” (2018, p. 7). This suggests that there is indeed a needed space for such positive feedback mechanisms, in either L1 or in EFL classrooms.

Other exercises appropriate for the EFL classroom which provide positive feedback may come in the form of an exercise introduced by Langmaid (2016), who focuses on developing and reinforcing ideas of hopefulness in the classroom. This is a vital project, as an increasing number of students in my classrooms in recent years have expressed significant pessimism regarding sustainability issues. Langmaid’s exercise incorporates personal reflection, collaborative discussion while creating a group poster, and a written vision statement describing how students see “themselves living in a flourishing sustainable society” (74).

4 Discussion

A wide range of classroom materials were investigated for their potential to introduce the concept of intersubjectivity to the EFL classroom. This work also identified similar texts or exercise that may be beneficial to the teacher of ESD in the EFL classroom. For exercises where student responses were collected, the overwhelmingly positive comments indicate that in the EFL classroom, students seem to be open to the introduction of intersubjective elements. Class conversations and private comments about the exercise indicated that the students found value in the activities. This was expressed both when the activity was a major focus—as a place-based writing assignment, for instance—as well as when the incorporation was minor, such as in a warm-up exercise. It should be noted, however, that this study did not seek to find a correlation between ESD in the EFL classroom and positive effects in ESD education. Rather, this research performs a revelatory function, as research suggests that little has been attempted before. Future work should be directed at determining the effects of an introduction of intersubjectivity in the EFL classroom on attitudes and knowledge regarding SD issues. In addition, the purpose of this research was to provide broad coverage of such class elements as texts, teaching units, and writing exercises. Further research should narrow that focus when considering the benefits of introducing intersubjectivity to EFL students.

5 Conclusion

The EFL classroom has been a location where certain SD topics are covered in a limited fashion within a larger topic base. Sustainable development is a global discourse and participation in that conversation primarily occurs in the English language. Students in the EFL classroom are in a prime position to benefit from an increased exposure to an SD lexicon and SD topics. While traditional education for sustainable development focuses on student awareness of issues and behaviors, psychology practitioners suggest that additional gains in student attitudes may be achieved by focusing on the ontology of humans and their relationships to Nature. Accordingly, this study has examined ways of introducing inner work and inter-subjectivity into the EFL classroom. Teachers should tailor work specifically to the levels in such a way that students see the value in approaching ESD from the point of view of Nature as an equal stakeholder in the SD issues that face us today and will provide the challenges of tomorrow.

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Sustainability Awareness in India

Kawaljit Kaur Batth

Abstract The research demonstrates the current situation in India in terms of sustainability awareness. India is a developing country and has the second-largest population in the world. India suffers considerably from various environmental problems like climate changes, resource depletion, e-waste, and various types of pollutions such as air, water, and soil. Various factors such as population growth, technology advancement, modern lifestyle, and industrial revolution are responsible for causing these environmental problems. Population growth is a major cause and has direct impacts on other factors. So, it is very crucial for India and other developing countries to move towards sustainable development in order to protect the environment and conserve the natural resources to meet the basic needs of the current and future generations. To achieve this, first of all, individuals and businesses need to examine the impacts that their activities have on their environment. Given all these issues, this research was conducted to identify the awareness level among Indian people of the sustainability benefits and risks. This research reveals the extent to which Indian people are aware of sustainability, whether they adopt sustainability strategies in their lives, and how their daily activities contribute to environmental problems. In India, the integration of sustainability is very important in various fields such as public and private organisations, education institutes, small businesses, and even individuals' lives to achieve sustainable development. Although numerous researches have been conducted on sustainability, no-one has focused on a particular country. So, this research is unique because it focuses on covering some aspects of sustainability in India only. The online survey research method was used to collect the data. A total of 142 surveys were distributed among Indian people using various online applications such as Facebook, Instagram, Gmail, WhatsApp, and LinkedIn. But only 102 valid responses were returned and were involved to analyse the data to obtain reliable and valid results. The research findings indicate that very few people are aware of sustainability and the majority of people have not even heard about sustainability. Indian people are not very concerned about the harmful effects of using electronic devices. They frequently replace their devices because they do not know how to reduce, recycle, and reuse them. They do not even think about e-waste

K. K. Batth (✉)
School of Management, Curtin University, Perth, Australia
e-mail: kawalbatth89@gmail.com

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when disposing of their old devices. Later, the survey findings were analysed to reveal new sustainability risks and opportunities. Moreover, the time constraints, incomplete surveys, problems in collecting data, and research scope are some of the limitations of this study. All these limitations can be overcome by conducting future research on related topics. The different research methods or the combination of various research methods could be used in future research to address these limitations. Finally, increasing the awareness of sustainability by offering a sustainability unit in educational institutions, awareness programs such as training, workshop, education, seminar, financial support from management, and proper knowledge of benefits and risks associated with sustainability before adopting sustainability in business areas, are some recommendations.

Keywords Sustainability · Sustainability awareness · Sustainability development goals · Triple bottom line · Corporate social responsibility · India

1 Introduction

The dissertation topic is related to "Sustainability awareness in India". There are numerous reasons for choosing this topic which will be discussed in this section. India is a rich source of natural, human, and renewable resources. But nowadays, all these resources are at risk for various reasons such as population growth, the industrial revolution, and modern lifestyle. Population growth has a major impact on other factors such as environmental issues, more consumption of resources, and more usage of electronic devices. Consequently, India suffers from various problems like environmental pollution, shortage of water and energy supplies, deforestation, corruption, political, and economic issues.

In India, pollution is a major problem in big cities such as New Delhi, Mumbai, and Chandigarh. In October 2018, according to WHO, New Delhi was at the top in the list of the 10 most polluted cities around the world. The World Health Organisation (WHO) estimated that approximately seven million people die each year due to air pollution. They found that the number of deaths due to air pollution is greater than from hunger, poverty, and natural disasters. In winter, the dust particles in the air affect the weather and produce thick smog. The villages in India are much less polluted than the cities because they do not face the same type of environmental issues such as air pollution. Moreover, rapid development, advanced technology, and manufacturing processes consume more natural resources and at the same time pollute the environment. Due to all these issues, it is vital that all Indian people be made aware of the concept of sustainability.

Hence, the major reason for selecting this topic is to investigate the level of sustainability awareness among Indian people. An online survey was distributed in a sample of the population to gather the data. A total of 142 surveys were distributed, of which 102 valid responses were returned. IBM SPSS 26 software was used to analyse the respondents' data. The survey results show that few people are aware of sustainability, while many people had never heard of sustainability. Moreover, some people believe that sustainability has only advantages. The lack of awareness among Indian people is the main obstacle in the sustainable development of the country. Awareness programs such as education courses or units, seminars, workshops, and training should be organized to spread sustainability awareness among people.

2 The Concept of Sustainability

The term ‘sustainability’ was initially developed from the older forestry term which was ‘sustain yield’ which referred to not continuing to harvest timber until it has been replaced with new growth, as explained by Kuhlman and Farrington (2010). According to Heinberg and Lerch (2010), this term was first used in 1713 by German forester and scientist, Hans Carl von Carlowitz, in his book titled “Sylvicultura Oeconomica”. At that time, Carlowitz’s main concern was to preserve the natural resources for the future generation with the sustainable use of forest resources.

The industrial revolution is the main cause of changing human lifestyles and their relationship with the environment. It began in the mid-1700s when machines were reduced manual labor and fossil fuel was used in place of wood, water, and wind for iron making processes. This transformation is known as the ‘industrialization of the world’ and had adverse impacts on human life and health, production, natural resources, energy usage, social development, and public well-being (McLamb 2011). Moreover, this revolution improved the living standards of human which resulted in a population explosion. Consequently, the use of energy, water, natural and human-made resources, waste by-products disposal also increased with the increase in population.

Although this revolution has made human life easier and more productive, on the other hand, it has adverse impacts on humans, the environment, natural resources, and society. In the 1960s, Rachel Carson made the public aware of the causes and harmful effects of the Industrial Revolution on humans and the environment. She described the detrimental effects of chemicals and human activities on the environment in her book named “Silent Spring”. She also raised a question about the impact of human activities on nature (McLamb 2011). This was the first time that the public became aware of sustainability, and industries started implementing sustainability in their business activities.

During the 1960s and 1970s, following the publication of Rachel Carson’s book, various other books were published that dealt with similar issues; these included Paul Ehrlich’s ‘The Population Bomb’ (1968), Edward Goldsmith’s ‘A Blueprint for Survival’ and Fritz Schumacher’s ‘Small is Beautiful’ (1973). In 1969, the concept of sustainable development was adopted with the US government’s National Environmental Policy Act (NEPA). This Act followed the Santa Barbara Oil Spill that had adverse impacts on natural resources, wildlife, birds, animals, and the environment. At the same time, different acts such as the Clean Water Act, the Water Quality Act pushed to ban DDT due to the concern for environment protection. In 1970, Earth Day was celebrated for the first time around the world. In early 1972, the term 'sustainable' was used in the modern sense named "Club of Rome" which is a part of the publication *Limits to Growth.* Its main aim is to explain a state in which the population realizes a balance in order to fulfil the basic needs of people.

After 15 years of Club of Rome's publication, nearly in 1983, the World Commission on Environment and Development (WCED) reviewed the most critical environmental and development issues faced by human beings around the world and formulated a specific proposal to address them. After this, in 1987, the Brundtland Commission in their report promoted the concept of sustainability on a global level. According to Brundtland report's, sustainability is a

> development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Robert et al. 2005, p. 10).

After the Brundtland report, its usage spread throughout the world and is still being used.

2.1 CSR

CSR has now become a key topic of discussion in government and other big businesses due to increasing environmental issues. In terms of business, CSR refers to operating the business processes in such a way that they meet the legal, commercial, public, and ethical expectations without doing harm to the environment. Most organisations main concern is to increase profits, but they have to be more concerned about how their business operations impact on the environment and the community (Attig et al. 2013). This section will explain CSR in detail and why CSR is required in businesses, as well as the types and roles of CSR. Finally, it will explain the numerous advantages and disadvantages of CSR from the business perspective.

2.1.1 What Is CSR?

CSR stands for Corporate Social Responsibility. CSR can be defined as an approach that contributes to sustainability through voluntary activities such as donations of time and funds (Moscardo et al. 2013). CSR encourages organisations to think about their social responsibilities towards stakeholders, workers, partners, consumers and their business operations and their impact on community and environment (Sridhar 2012). Erek et al. (2009) state "sustainability has been extensively discussed within corporate management under the synonyms of corporate social responsibility, greening the business, eco-efficiency or eco-advantage". CSR occurs when companies manage their economic operations to produce only positive impacts on society in order to improve peoples' lives.

Furthermore, by implementing CSR policies, companies show concern for the environment and society by engaging in various social activities related to donations, safety, corporate citizenship, or philanthropy (Høgevold et al. 2015). The key objective of CSR is to reduce the negative impacts of economic processes on society, people, and an environment by addressing a wide range of categories. These are environmental sustainability, employees' rights, legal and honest operations, global citizenship, human rights, suppliers, customers, competitors rights, honest and transparent accountability (Fenwick 2007). Carroll (1991) states that if company managers can become moral then social responsibility can be achieved easily.

2.1.2 Why CSR?

Both individuals and the community face many challenges with growing organisations because as the organisation increases, the demands are increasing and natural resources are declining, as stated by Høgevold et al. (2015). Environmental problems arising from business operations have now become a key issue and have harmful effects on human health. Today, CSR provides several benefits to companies, societies, and communities (Forte 2013). Figure 1 demonstrates the various benefits of CSR adoption by businesses. In this case, CSR makes organisation socially responsible towards the environment and human beings by evaluating how their business processes impact on social well-being. Attig et al. (2013) mentioned that socially irresponsible firms are experience high risks compared to socially responsible firms. Similarly, firms with poor social performances contribute to more pollution and violations as compared to other firms.

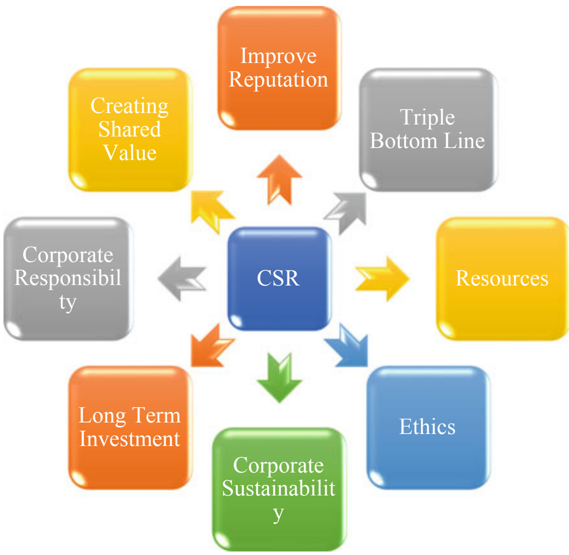


Fig. 1 Corporate social responsibilities (Rangan et al. 2012). Prepared by: Kawaljit Kaur Batth

As the name implies, CSR is made up of three words Corporate, Social, and Responsibility which defines the roles of business for society and environment. Nowadays, the primary responsibility of every business is to create value for its customer which in turns create value for society and benefits for the business. Corporate refers to a big organisation that performs several activities to make profit. Social means a group of people living in the same society and they focus on to contribute to sustainable development by taking care of society, economic, and environment. Responsibility means results produced from the operations taken for developing business.

2.1.3 Types of CSR

After the mid-1970s, organisations start adopting CSR in their businesses to move towards sustainability. After adopting CSR, organisations take social responsibilities for society, economy, and environment (Smith and Sharicz 2011). According to Carroll (1991), a complete CSR is made up from four types of social responsibilities: economic, legal, ethical, and Philanthropic which is shown in Fig. 2 firm managers and employees play a critical part in social activities within their local community.

There are mainly four types of CSR which are given below:

(1) Legal responsibility: Businesses focus on reducing the negative impacts of the technologies they designed, produced, and used. Carroll (1991) mentioned that

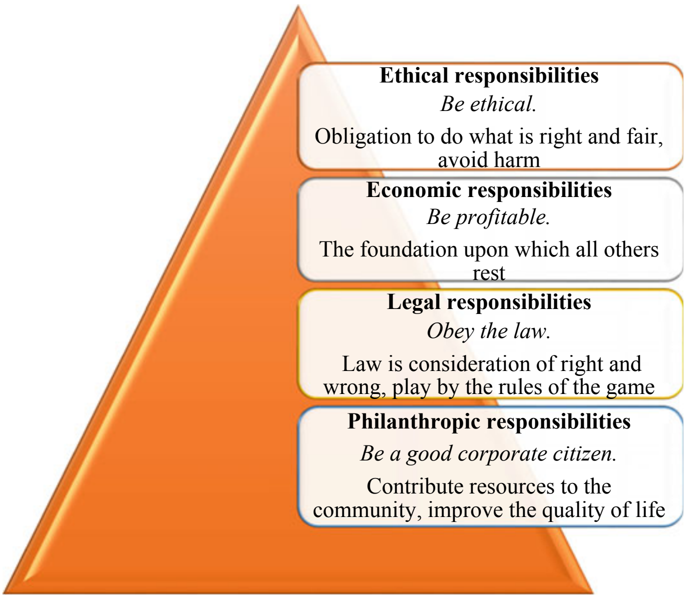


Fig. 2 Types of CSR (Croall 1995). Prepared by: Kawaljit Kaur Batth

organisations must produce goods and services by meeting the legal requirements. Organisations should obey the various government laws such as federal, state, and local laws in order to recognize what is wrong and right for the society.

(2) Philanthropic responsibility: In terms of philanthropic responsibility, firms focus on direct funding or donation of goods and services to non-profit organisations, community, and poor populations (Rangan et al. 2012). As mentioned by Carroll (1991), managers' and employees' involvement is very important to perform volunteering activities which may lead to improving the quality of life of people living in their local community.

(3) Ethical responsibility: The two major responsibilities of a big organisations are economic and legal. After meeting the basic requirements of a company, the ethical responsibility of every business is to promote a healthy and safe environment for the community or workplace (Fenwick 2007). Moreover, they are required to behave ethically towards firms' stakeholders, pay fair wages to its employees, take care of their health and safety, and provide friendly environment to work to avoid damage, harm or social injuries. Moreover, Sharma (2018) states that education plays a critical role in developing ethical awareness.

(4) Economic responsibility: Corporations have not only legal and ethical responsibilities but economic and philanthropic responsibilities as well (Carroll 1991). In terms of economic responsibility, a company's first concern should be its profit because it is essential to maintain a strong and long-term position in the market and high level of operating efficiency (Carroll 1991). Otherwise, a company will not be able to contribute to environmental sustainability and be concerned about social responsibility. Nidumolu et al. (2009) state that leadership and knowledge play an important role in business development.

2.1.4 Roles of CSR

The main aim of CSR is to integrate environmental, economic, and social dimensions in business management for a cleaner environment and better society (Smith and Sharicz 2011). According to Rangan et al. (2012), CSR has different responsibilities towards different people in a business which are shown below:

(1) The responsibilities towards investors: An organisation should respect all stakeholders, reveal all necessary information to their shareholders, and maintain a strong and long-term relationship with them to keep confidentiality of internal information more secure and private. Rangan et al. (2012) mentioned that the main purpose of CSR is to create a shared value for its shareholders but in such a manner that it also creates value for society. According to Sadok El et al. (2016), CSR helps companies to maintain trust, goodwill, and long-term relationships with external stakeholders.

(2) The responsibilities towards employees: The firm's social performances can measure the firm's ability to generate trust and loyalty with their employees in the workplace. Corporations should pay fair wages to their employees, provide a secure and healthy environment, provide training to their new staff members

to develop their technical and practical skills, and improve employment quality (Sadok El et al. 2016). According to (Weber 2008), CSR activities such as volunteer programs positively motivate employees to work for the local community which may lead to improving company reputation.

(3) The responsibilities towards consumers: A business with CSR initiatives can achieve more benefits from consumers because customers are more likely to switch from one brand to another depending upon both the quality and price (Du 2013). An organisation must provide good quality products and services to their consumers, look after their health and safety, respond in an appropriate way to their complaints, and behave ethically. Sadok El et al. (2016) state that consumers have more concern about product quality and long-term goods and services agreement which may help to increase a firm's profitability.

(4) The responsibilities towards business partners: Corporations focus on minimizing the business operations' negative impact on people, society, and environment in order to enhance value for their business partners and other stakeholders (Erek et al. 2009). Funding plays an important role in business. CSR helps to increase investments from business partners (Weber 2008). Green (2012) claims that CSR improves company reputation, its brand image, and good business practices to develop a strong relationship with business partners. The partnership between public and private sectors ensures the best use of the capital investment, time, and energy.

(5) The responsibilities towards community and environment: Corporations measure the impact of their business performances on the complete ecosystem including natural systems such as air, water, land, soil, and the social community (Sadok El et al. 2016). Corporations must support local workers and create and implement strict policies to protect the environment from the negative impacts of business processes.

2.2 Advantages and Disadvantages of CSR

The growing concern about sustainability has increased the implementation of CSR in companies to provide benefits to them. In terms of business benefits from CSR, it can be of two types, monetary and non-monetary as shown in Fig. 3 Monetary benefits can be measured in terms of money whereas non-monetary benefits are those benefits that cannot directly measured in monetary terms. According to Weber (2008), non-monetary benefits can be measured by quantitative and qualitative indicators such as company reputation, changes in repurchase rates, customer attraction, and employee motivation.

Advantages of CSR

The main reason for implementing CSR is to increase the positive impacts and to decrease the negative impacts of their business operations on environment and society. A company derives benefits from CSR in terms of reputation, employee

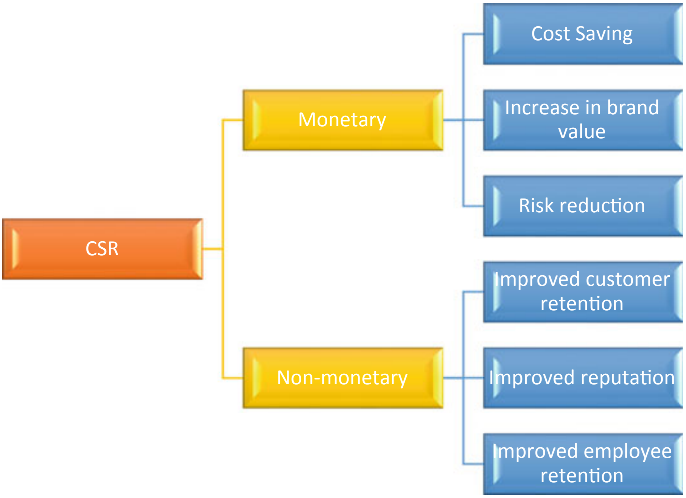


Fig. 3 CSR benefits to business (Weber 2008). Prepared by: Kawaljit Kaur Batth

motivation, cost savings, and risk reduction. The various advantages of CSR are given below.

(1) Improve reputation: CSR might not offer a direct benefit to an organisation, but it can enhance its business image and reputation in the market. CSR investments improve the business reputation which may help to increase customer trust and loyalty and to attract new customers. In CSR policy, philanthropy is an action in which a company donates money and services to people and community who need it; it may include hosting a charitable event which shows that a company not only focuses on making profit for itself, but also helps people and its society (Rangan et al. 2012). They may provide a free service to local people and businesses and undertake a charitable project for the socially and environmentally disadvantaged in poor areas. CSR helps to improve community welfare and create a better living environment.

(2) Fulfil employees' expectations: The key objective of a business is to enable employees to fulfil their potential (Urmee et al. 2016). CSR helps to maintain a strong and long-term relationship with individuals, employees, community, companies, and other business partners. A company with CSR provides good wages, and a healthy and secure environment to its employees which positively influences employee performance and attitude and fulfils their expectations. CSR policy's main concern is to provide secure and friendly environment to its employees to prevent harms, social injuries, and to protect a company from destruction. Consequently, it improves the business ethics.

(3) Cost savings: The implementation of CSR in a business may result in cost and time savings. In terms of efficiency, CSR policy analyses the use of natural resources such as energy, water, air, or land and takes appropriate action to

reduce their usage for both environment benefits and cost reduction (Weber 2008). For instance, the use of renewable energy sources instead of fossil fuels may reduce costs in the long-term.

(4) Increased sales: CSR also helps to increase business sales. Employee satisfaction and customer loyalty may directly help to improve company status in the market. For example, a customer is often ready to pay more for an organically produced item. CSR builds a strong relationship between business and customer. With the help of CSR, a company is able to meet customer needs and therefore increases the sales volume.

(5) Risk reduction: The negative impacts of business processes on environment and society can be reduced with the help of CSR. In CSR policy, communication and reporting are important components which helps the company to understand local community needs. A company measures its activities' impact on environment and society to generate a CSR report on.

Disadvantages of CSR

Although CSR offers numerous advantages to a company, it has several disadvantages too. These are given below:

- Large organisations can afford CSR initiatives, but it can be expensive for small organisations.
- In a company, conflict of interest between different departments can occur.
- Different companies used different methods for analysing and reporting.
- Most companies adopt CSR for their personal benefits only.
- CSR companies do not realise instant benefits, but customers expect quick delivery of services and goods, and failure to deliver may negatively affect the company reputation.
- CSR companies might not have skilled and experienced employees which may present instead of profit.
- Poor social and environmental performances may lead to loss, or negatively affect the company's reputation in the market.

2.3 Triple Bottom Line (TBL)

The term triple bottom line (TBL) was first introduced by John Elkington in 1990 to describe environmental, economic, and social investments value to think outside the profit bottom-line. TBL is also known as the 3P'-s-: people, planet, and profit (Hammer and Pivo 2017). Figure 4 depicts the three main pillars of TBL. TBL is used to describe the involvement of businesses in sustainability, the three main components of which are the economy, environment, and society (Kuhlman and Farrington 2010). It is designed to measure an organisations performance and success in terms of these three pillars not only now but also in the future.

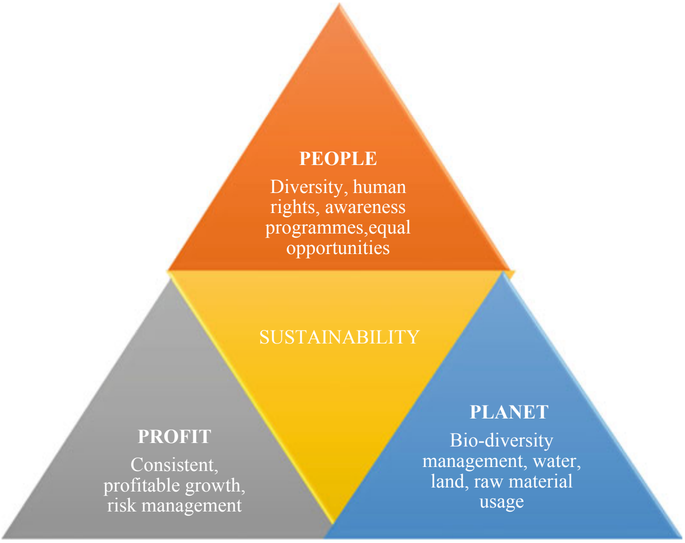


Fig. 4 Triple bottom line (Bala 2016). Prepared by: Kawaljit Kaur Batth

The main objective of TBL is to reduce the negative impacts of business operations on these three dimensions in order to remove poverty, save natural resources, change unsustainable patterns of production, and implement business practices that will protect the society and environment. Smith and Sharicz (2011) define the term TBL sustainability as organisations activities impact on the world to demonstrate the business ability to maintain the business operations without negatively affecting social or ecological systems.

Moreover, companies not only focus on profit-bottom line, but also adopt triple bottom line perspective in their business operations which includes society, economy, and ecosystem (Smith and Sharicz 2011). Finally, in today's competitive world, organisations not only use resources for their financial benefit, but also for social and environmental benefits.

2.3.1 People

For businesses, social sustainability means the ability to maintain trust, loyalty, and a good relationship with stakeholders, supply chain partners, employees, unions, consumers, and society in the long term (Sridhar 2012). Most businesses' effort towards social sustainability are through charity and volunteering programs (Heinberg and Lerch 2010). Some social variables can be measured in terms of unemployment rate, human rights, security, women ratio in workforce, freedom, education quality, equity, poverty and crime rate in a society, life expectancy, equality in facilities and resource allocations, respect among people, health and wellness, quality of product and education, and living standards need to be measured (Hammer and Pivo

2017; Willard 2012). To achieve social sustainability, most large companies focus on providing a secure and better working environment for their employees to improve their motivation, health safety, knowledge and skills which may directly or indirectly enhance the companies' reputation.

2.3.2 Planet

Environmental protection is very important for human existence. In today's business world, the excessive use of IT devices in personal life or in workplaces contributes to the rising environment issues because they discharge harmful greenhouse (Erek et al. 2009). Hence, e-waste and climate change have now become the most critical environmental problems in the world (Ansari et al. 2010). Majeed (2018) indicates that Bangladesh suffers most from these two environmental problems. These problems have a direct impact on the human health. Similarly, limited natural resources are now are at risk with these environmental problems.

Company managers need to take social responsibility seriously by thinking about how business operations and decisions impact on the environment (Smith and Sharicz 2011). Bala (2016) also mentioned that there is need to measure some variables for environment improvement. These may include quality of air, usage of water, natural resources, land, solid and toxic waste, and usage of fossil fuel and electricity, and energy consumption.

2.3.3 Profit

In a competitive world, every organisations main concern is to make profit with or without affecting the environment and human life. In terms of economic sustainability, many organisations have started identifying products' impacts on environment and focus on designing sustainable products. Companies can make profit by producing goods and services using eco-friendly resources to offer higher quality of life and value to consumers (Elkington 1998). Moreover, according to Bala (2016), economy sustainability refers to business growth, productivity, profit, expenses, taxes, employment rate and diversity. Different variables such as income of the employee, growth in job opportunities, employment rate in each sector, profit contribution in GDP (Gross Domestic Product) are used to measure economy factors in businesses because these variables have a direct link with finances and the bottom line.

3 Research Question and Research Method

As mentioned above, although India is a developing country, it is a rich source of natural resources. It has a large number of rivers, lakes, oceans, and large areas of forest. But at present, these resources are at risk due to the modern industrialization and the increasingly competitive development. Every day the level of fresh water is diminishing due to the misuse of water, and the remaining water in rivers, lakes, and oceans is becoming polluted by the dumping of e-waste. Nowadays, the lack of good drinking water has become the worst problem in some regions in India. India has the world's second-highest population. Due to the population growth, the use of technology in India is very high, which has increased the problems of e-waste and climate change. India is not only facing environmental problems but social and economic ones as well because of the unsustainable development.

3.1 Research Question

The primary research question was formulated by analysing the current situation of India in terms of sustainability. The primary research question clearly simplifies the purpose of conducting this research. The primary research question of this research is:

What are the benefits and risks of sustainability awareness in India?

The key objective of this research is to spread awareness of sustainability among Indian people and to examine the benefits and risks of their sustainability awareness. To find the answer to this question, an online survey was distributed among Indian people in order to determine Indians' attitudes and behaviours regarding sustainability in order to determine their awareness level. In the online survey questions, various factors such as age, gender, and education level were considered to examine the mindset of Indian people when purchasing and shifting to new IT devices. The survey results show how many people are familiar with the notion of sustainability, and the extent to which they contribute to environmental problems by using IT devices either for business operations or personal use.

Online survey results demonstrate that there is a need to take some actions to make Indian people more sustainable in order to eliminate the problems they are facing at present. Finally, the research provides accurate information about the various benefits and risks of sustainability awareness in India.

3.2 Research Method

There are mainly two types of research methods—quantitative and qualitative. But the selection of a research method depends upon the various factors such as the type of research question, objective of the research, researchers' view on reality, and the conclusion. The research method selected for this research is quantitative because the research question is related to respondents' views, feelings, and attitudes toward sustainability in India. An online survey research method was used to collect the data. An online survey has now become an important tool for conducting quantitative research. An online survey was designed, distributed, and analysed with the help of software. In this research, it was distributed vis online applications among Indian people in different locations in order to discover their level of sustainability.

The survey questionnaire was divided into three sections. The first section contains questions related to each respondent's age, gender, occupation, and education level. The questions in the second section were designed to discover the respondents' behaviours and attitude to technology and its usage; specially types of electronic devices they use to access the internet, how much time they spend on the internet, emails, and social networking sites each day, for what purposes they use them, how often they and for what reason replace their devices. The last section was intended to elicit respondents' personal opinions regarding sustainability risks and advantages in order to analyse their level of sustainability awareness. This research employed a unit of analysis survey and was independent of the researcher's view.

3.3 Quantitative Research Method

As its name implies, a quantitative research method is used to measure the quantity. It is also known as the deductive approach. Quantitative methods produce numerical data by using various mathematical notations. The quantitative research method is used when findings are related to a population or there is a need to test a theory mathematically. It is mainly used in natural and social sciences including biology, physics, psychology, geology, and sociology (Sukamolson 2007). The quantitative method is also useful for conducting and estimating the size of audience segments.

Furthermore, it is a more useful method for computing opinions, views, behaviours, and attitudes and to find out how the population thinks or feels about a certain problem or issue. It is also the most appropriate for the testing of hypotheses. According to Malina et al. (2011), quantitative research basically answers those research questions that address 'how many' and 'how often'. Issa (2013) states that the online survey has now become an important tool for conducting quantitative research as it provides accurate, rich and historical information. Figure 5 demonstrates the common approaches to quantitative research.

4 Results

The online survey link created through the Qualtrics software was distributed among 142 Indian people by using different online applications such as WhatsApp, Facebook, Gmail, Instagram, and Messenger to collect the data. Only 102 survey responses were valid and were analysed to evaluate the survey results. Table 1 shows the percentages of online survey questionnaires distributed and those returned.

Fig. 5 Common approaches to quantitative research (Sukamolson 2007). Prepared by: Kawaljit Kaur Batth

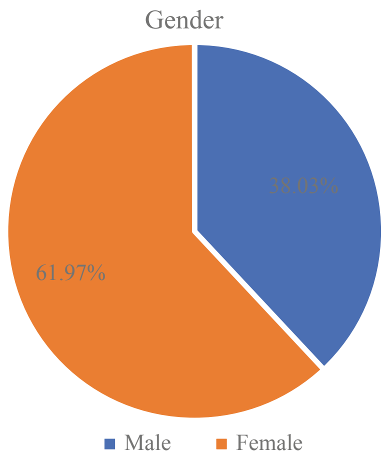
Table 1 Number of percentages of online survey. Prepared by: Kawaljit Kaur Batth

Questionnaires distributed	Questionnaires returned	Response rate
142	102	72%

4.1 Gender

Chart 1 shows the total gender distribution as percentages. It indicates that 38.03% of participants are males, whereas 61.97% are females. Therefore, more females than males participated in the survey.

Chart 1 Total number of participants based on the gender. Prepared by: Kawaljit Kaur Batth



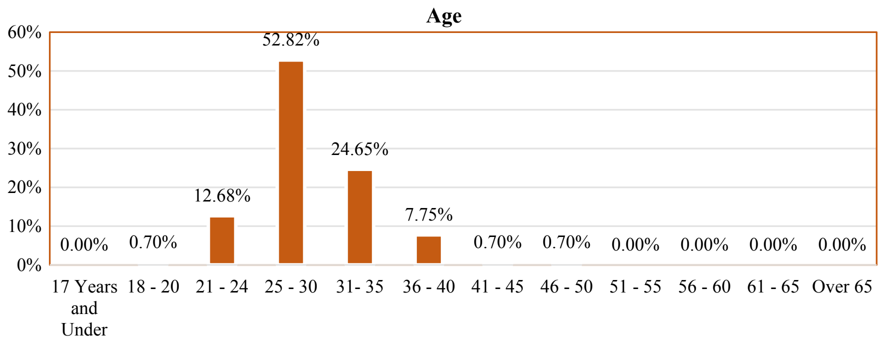


Chart 2 Contribution of participants based on the age group. Prepared by: Kawaljit Kaur Batth

4.2 Age

Chart 2 shows the distribution of participants according to age. It indicates that people aged 21–40 years participated in the survey. The majority of respondents (52.82%) were aged between 25 and 30; no-one was aged under 17 or above 51. Finally, 24.65% were aged between 31 and 35, 12.68% from 21 to 24 ages, and only 7.75% from 36 to 40.

4.3 Education Level

Chart 3 shows the highest level of education achieved by respondents. Students completing a master's degree accounted for 63.70% of respondents, while the lowest score of 0% was for students completing a Ph.D. Bachelor's students contribute

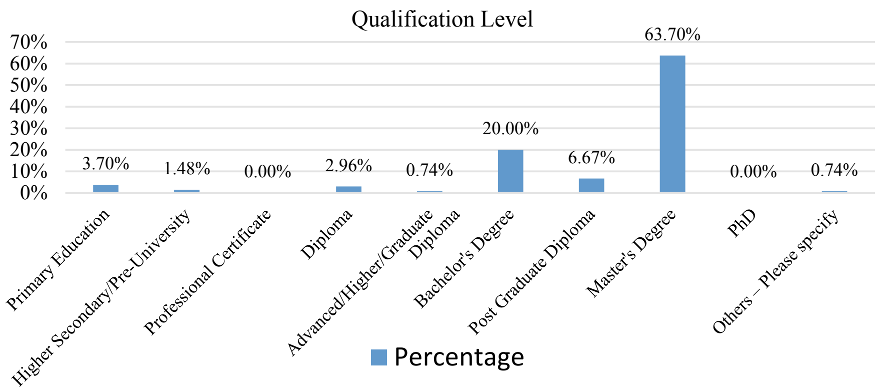
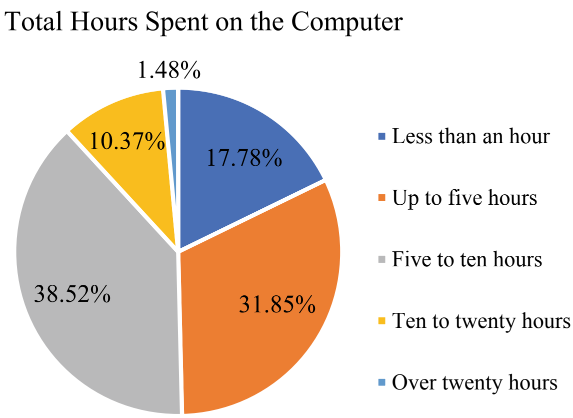


Chart 3 Qualification level of the participants. Prepared by: Kawaljit Kaur Batth

Chart 4 Total hours spent on the computer by respondents. Prepared by: Kawaljit Kaur Batth



to 20%, followed by the postgraduate students for 6.67%. Those with a diploma accounted for 2.96%, while 3.7% had a primary education as the highest level reached.

4.4 Number of Hours Spent on the Computer Per Day

Chart 4 indicates that 38.52% of respondents use a computer for five to ten hours daily, whereas only 1.48% use it for over twenty hours. Moreover, 31.85% of respondents spend up to five hours on a computer and 17.78% use it for less than an hour. Only 10.37% of respondents spend ten to twenty hours on the computer each day.

4.5 Total Hours Spent on the Internet Per Day

Chart 5 indicates the respondent's daily usage of the internet. It shows that the highest proportion of respondents (50.37%) spend up to five hours daily on the internet but very fewer (1.48%) use the internet for over twenty hours. Only 6.67% of respondents use the internet for less than an hour, 28.89% for five to ten hours, and 12.59% for ten to twenty hours. These results show that almost all respondents have access to the internet.

4.6 Total Hours Spent on the Social Networking Sites Per Day

Chart 6 reveals the respondents' daily usage of the internet to access social networking sites. Of the respondents, 51.88% spend less than an hour on social networking sites

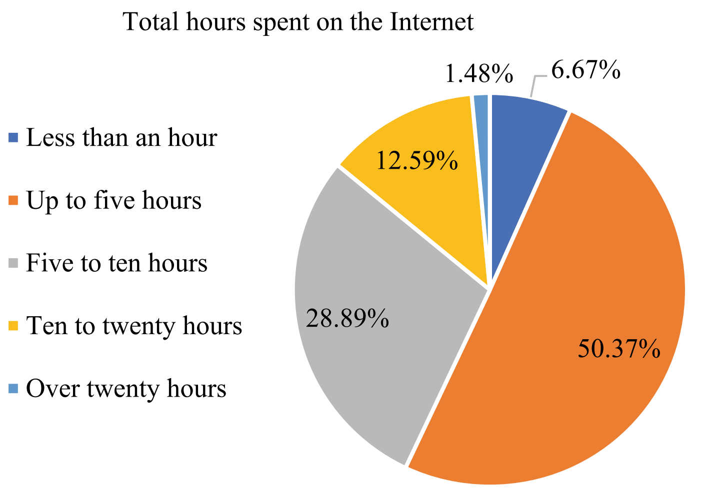
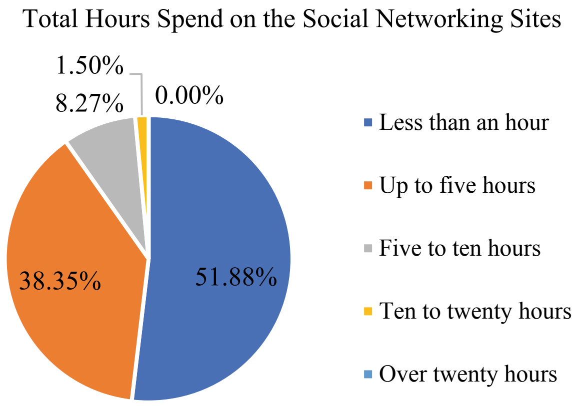


Chart 5 Internet usage by the respondents. Prepared by: Kawaljit Kaur Batth

Chart 6 Use of the internet for social networking sites. Prepared by: Kawaljit Kaur Batth

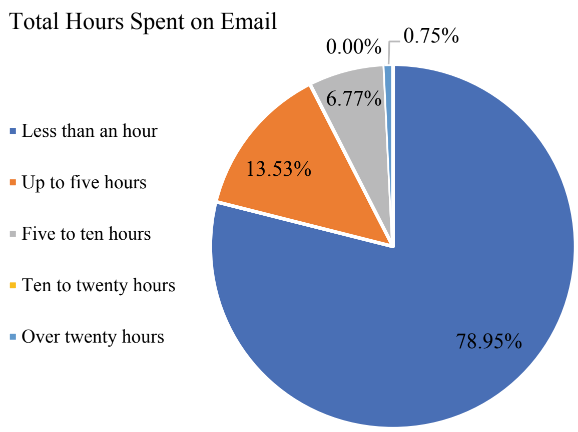


such as Facebook and Instagram, whereas very few people (1.50%) spend a great deal of time (ten to twenty hours) on the internet to check their social networking sites. Furthermore, 38.35% of respondents spend up to five hours and only 8.27% use it for five to ten hours. No-one spent over twenty hours on social networking sites.

4.7 *Number of Hours Spent on the Email Per Day*

Chart 7 shows the number of hours spent by respondents on emails. The majority (78.95%) of respondents use the internet for less than an hour to check their email,

Chart 7 Time spent on the email by respondents. Prepared by: Kawaljit Kaur Batth



whereas a very few people with a percentage of 0.75 spend over twenty hours which is really surprising. Only 13.53% of people spend up to five hours, followed by 6.77% who spend five to ten hours. As the chart shows, no-one spends ten to twenty hours on emails.

4.8 The Use of the Internet for Different Purposes in a Day

Chart 8 shows the various purposes for which people use the internet. It shows that 15.41% of respondents use the internet for checking their emails, 6.16% for playing games, 14.33% for searching materials related to study, and 11.86% related to a job. Additionally, the use of the internet for online shopping, chatting, banking online contributed to 10.79%, 14.33%, and 11.56%, respectively. Additionally, the remaining activities such as buying goods or services, buying stocks or investing online, researching travel information or making reservations contribute to less than 6%.

4.9 The Use of Various Devices to Access the Internet

Chart 9 illustrates the percentage of the various devices used by respondents to access the internet. The majority (33.92%) of respondents use smartphones, whereas 29.79% use laptops. The percentages of those using PCs and desktops are 14.16% and 10.62% respectively. Very few participants use PDAs and workstations, indicating that they are not familiar with these devices. Tablets were used by approximately 7.37% of respondents.

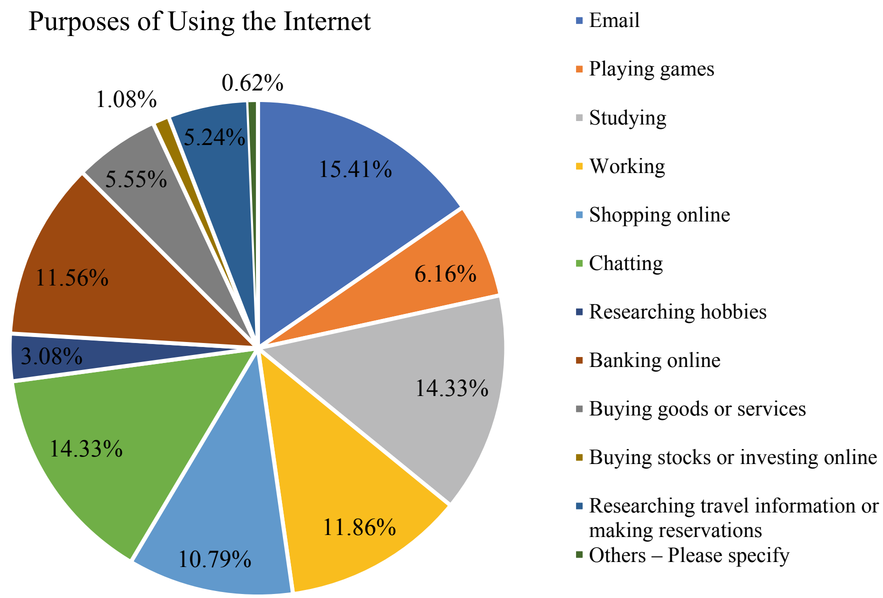


Chart 8 Different purposes of internet usage. Prepared by: Kawaljit Kaur Batth

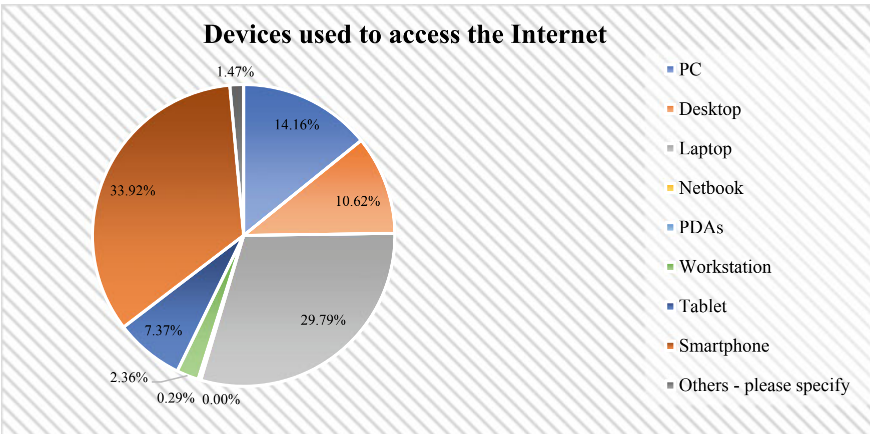


Chart 9 Devices used to access the internet. Prepared by: Kawaljit Kaur Batth

4.10 Respondents First Introduced to Sustainability

Chart 10 shows that the highest proportion (33.49%) of respondents were first introduced to the sustainability concept during their higher education studies, whereas a very few were introduced through conferences and other sources. School and the

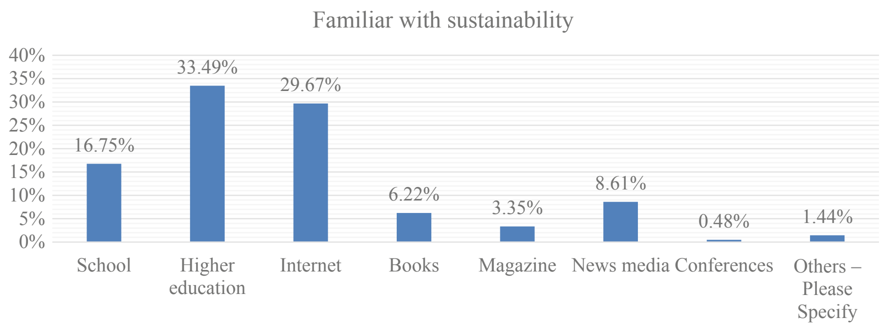


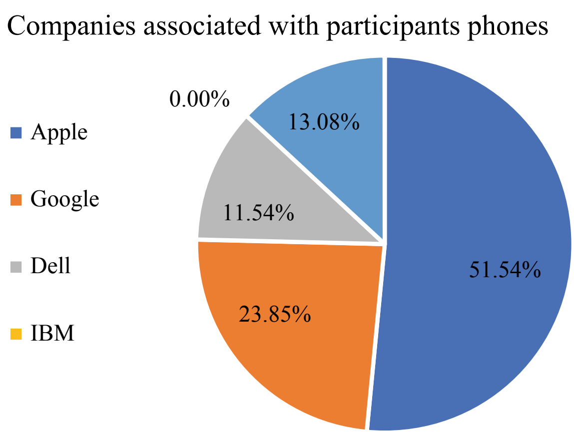
Chart 10 Respondents first introduced to sustainability. Prepared by: Kawaljit Kaur Batth

internet play a vital role in introducing sustainability concepts to people, accounting for 16.75% and 29.67% respectively. Moreover, only 9% of respondents were introduced through books, magazines, and news media.

4.11 Companies Associated with Respondents' Phones

Chart 11 indicates the percentage of companies whose phones are bought by respondents. The majority of 51.54% used Apple devices; 23.85% used Google devices; 11.54% used DELL company devices, and no-one used IBM devices. Finally, 13.08% of respondents use devices manufactured by Nokia, Samsung, Sony, and Lenovo.

Chart 11 Companies associated with respondents' phones. Prepared by: Kawaljit Kaur Batth



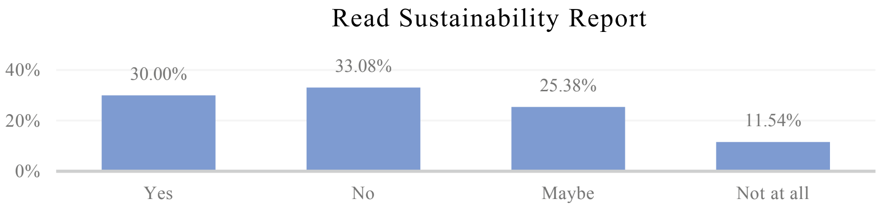


Chart 12 Number of respondents who read sustainability reports. Prepared by: Kawaljit Kaur Batth

4.12 Respondents Read Sustainability Report

Chart 12 indicates how many respondents read the sustainability report before buying new devices. It shows that 33.08% of respondents do not read the sustainability report, whereas 25.38% do so occasionally. Furthermore, 30% of respondents stated that they always read the report, but a small number (11.54%) admitted that they never read the sustainability report before buying new devices. This indicates that they are not very aware of sustainability.

4.13 How Often Respondents Change Devices

Chart 13 indicates how frequently respondents change their devices. Devices are changed every two years by 18.46% of respondents. The number of respondents who change devices after every 36 months and 42 months has the same percentage which is 13.08%. Similarly, 10.77% of people upgrade their devices every 12 months and the same percentage every 18 months. Very few people (3.08%) switch to new devices frequently.

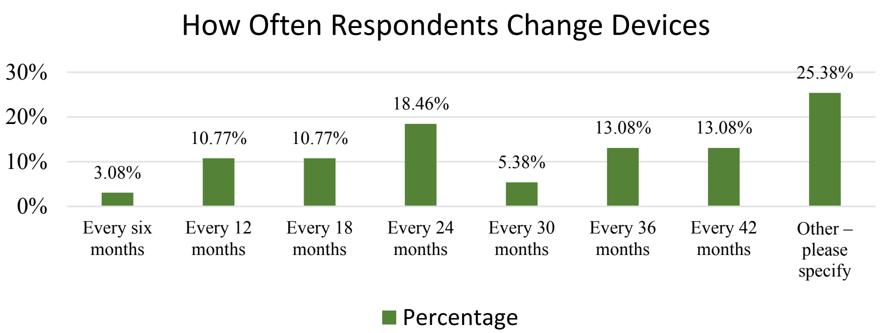


Chart 13 How frequently respondents change devices. Prepared by: Kawaljit Kaur Batth

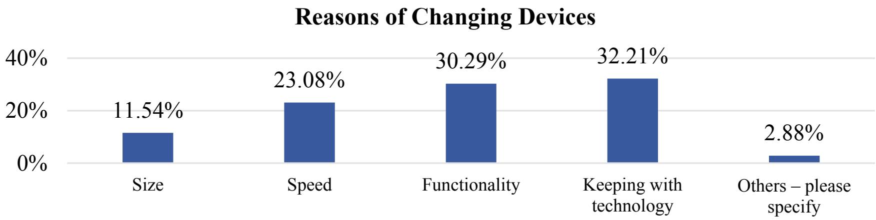


Chart 14 Reasons behind changing devices. Prepared by: Kawaljit Kaur Batth

4.14 Reasons Behind Changing Devices

Chart 14 indicates the reasons why respondents change their devices. It shows that an average of 32.21% of respondents change their devices up to date with the technology, while 30.29% of people change due to the device functionality. The size and speed are other reasons for changing devices which contribute to 11.54% and 23.08%, respectively. Very few people (2.88%) change their devices because new models have better features.

4.15 An Indian People Views Regarding Damage to the Planet

Chart 15 shows the respondents' opinions regarding the replacement of devices. It indicates that the highest proportion (46.08%) of people believe that there might be damage to the planet by frequently changing devices but were not sure, whereas 40.20% believed that there is an adverse impact on the planet by changing devices, whereas 8.82% people have opposite views. Only 4.90% of people were not sure about this.

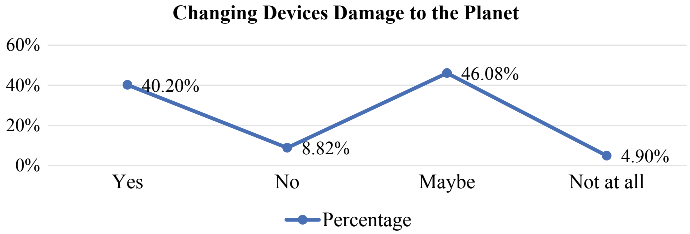


Chart 15 Changing devices damage to the planet. Prepared by: Kawaljit Kaur Batth

4.16 Methods to Change the Users and Designer's Mindset

Chart 16 demonstrates the various methods that can help to change the users' and designers' mindsets in regard to becoming more sustainable in their lives. It shows that 18.85 and 18.40% of the respondents believe that the users' and designers' mindsets can be changed through awareness and education, respectively. Almost 15% of people believe that training, internet, and social networking sites are the best methods to shift the user's mindset towards sustainability. Very few people are in favour of TV.

5 Discussion and New Findings

The research focuses on the implementation of sustainability in the real world. This research gives a deep knowledge of many issues associated with sustainability benefits and risks. The data collected through the online survey was analysed to generate new benefits and risks of sustainability. The survey results can be beneficial in making decisions about the adoption of sustainable development and can be used as a secondary source in future research.

The research results satisfactorily answer the research question which was:

What are the benefits and risks of sustainability awareness in India?

The five new factors generated for sustainability benefits and risks will hopefully encourage Indian people to adopt sustainability practices in their daily activities. It may change Indian people's mindset, thinking, and behaviour in regard to sustainability. Moreover, it may assist businesses to become more sustainable in manufacturing by using only ecofriendly products. Figure 6 shows the new risks and opportunities generated from the survey analysis.

The survey findings indicate that some Indian people think that sustainability provides benefits only. They believe that it helps to reduce risk management, increases

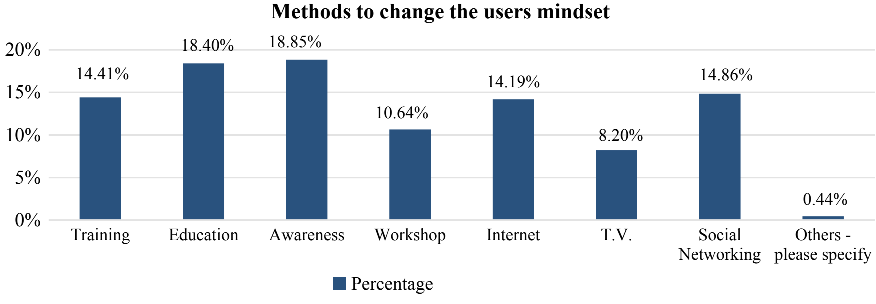


Chart 16 Methods to change the designers and user's mindset. Prepared by: Kawaljit Kaur Batth

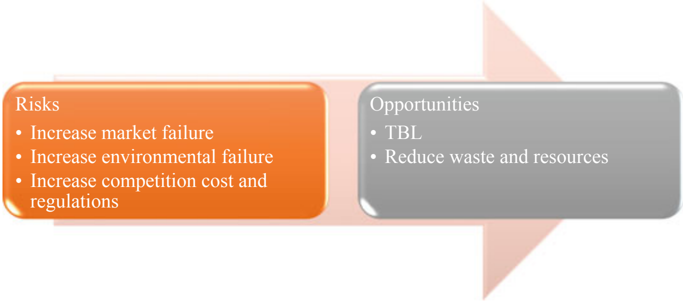


Fig. 6 New sustainability risks and opportunities. Prepared by: Kawaljit Kaur Batth

the triple bottom line (TBL), improves social responsibility, improves community investments, reduces pollution, reduces energy, water and paper usage, reduces carbon footprints, creates new jobs, reduces emissions, and attracts new opportunities. All these advantages have factor loadings of 0.7. Moreover, sustainability increases green strategy, attracts quality employees, enhances reputation, differentiates businesses, increases efficiency, meets stakeholder expectations, improves corporate social responsibility, reduces consumption of raw materials, and reduces health hazards; these benefits have a factor loading of 0.6.

Finally, two new sustainability advantages are generated from all these benefits: TBL and reduction of waste and consumption of resources. Figure 7 illustrates the new sustainability opportunities.

In contrast, some people believe that sustainability not only offers benefits but also has some drawbacks. It increases competition for and cost of raw materials and increases the risk of marketing failure. These two risk factors have 0.8 factor

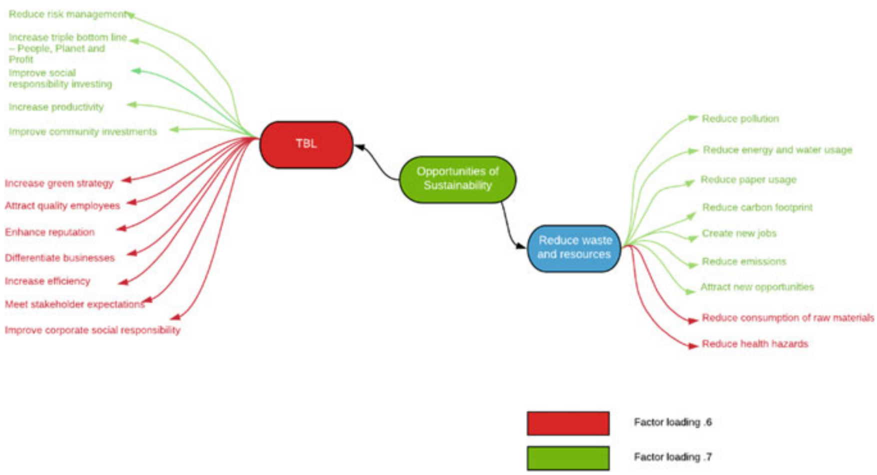


Fig. 7 New sustainability opportunities. Prepared by: Kawaljit Kaur Batth

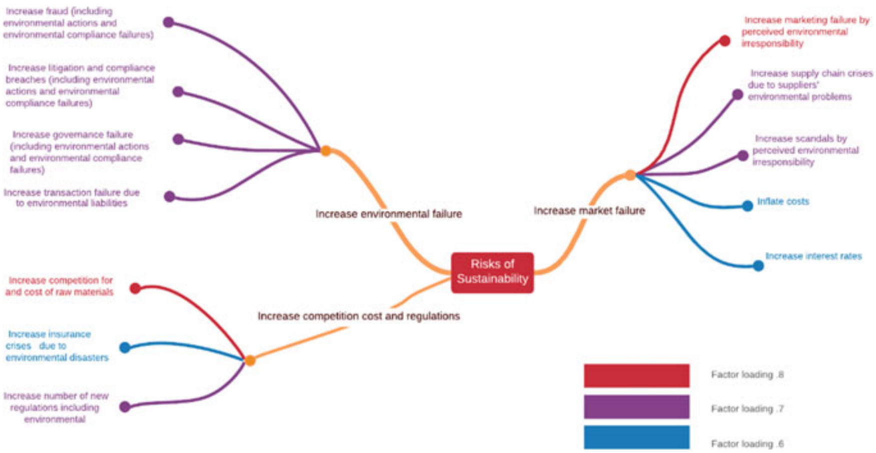


Fig. 8 New sustainability risks. Prepared by: Kawaljit Kaur Batth

loadings. Respondents believe it also increases insurance crises and interest rates and will inflate costs which have factor loadings of 0.6. Moreover, it increases the possibility of transaction failure, supply chain crises, scandals, security and systems failures, governance failure, litigation and compliance breaches, and fraud. All these risks have factor loadings of 0.7. Figure 8 illustrates the new sustainability risks generated from the data analysis.

6 Limitations

Although the research findings provide a satisfactory answer to the research question, the research is not free from limitations. This research had limitations in terms of time, the study scope, incomplete surveys, and issues related to the data collection process. These limitations are discussed below.

6.1 Time

Time constraint was the major limitation of this research because it had a direct impact on the research quality. The maximum time period for completing this research was only two months which was very short. Consequently, sufficient data was not collected.

6.2 Incomplete Survey

The second major limitation of the research was the number of incomplete surveys that were returned. It was very challenging to follow up with the participants and encourage them to complete the whole survey. Most people did not complete the whole survey and therefore those responses were not involved in the data analysis. Only the data in the completed surveys were analysed to obtain reliable and valid results.

6.3 Data Collection Problems

The various online applications such as WhatsApp, Facebook, Instagram, and Gmail were used to distribute the survey link among Indian people. However, it was very difficult to collect the data via these channels because there was no face-to-face communication with the participants. Moreover, most people are not familiar with the concept of sustainability and some believed that it was time-consuming. So, because of the absence of the researcher, it was very difficult to clarify some terms to the participants.

6.4 Sample Scope

The online survey was disseminated among Indian people living in small cities and villages only. Indian people living in large cities were not involved in this sample. Therefore, those people's opinions are not known. Hence, the size of the sample was very small and limited.

6.5 Research Scale

This research surveyed only Indian people's opinions regarding sustainability benefits and risks in order to identify sustainability awareness among Indians. Thus, the other issues related to sustainability were outside the scope of this research.

7 Future Research

The entire study focuses on answering the research question: "What are the benefits and risks of sustainability awareness in India?" To answer this question, the data was collected. The online survey research method was used to gather a range of opinions regarding sustainability. As mentioned above, the research results satisfactorily answer the research question but, on the other hand, it has some limitations in terms of time, scope, problems with the data collection, and incomplete surveys. Future research is needed to address these limitations. Further research can be done at a global level to examine the other issues associated with sustainability which are not considered in this study. Moreover, different research methods can be used to analyse and refine the research results.

Finally, the research findings can be used as secondary data in future research endeavours. The relevant information presented here on various aspects of sustainability will help future academic researchers to explore their ideas.

8 Conclusion

In conclusion, the research findings, limitations and several recommendations for future research are given in this chapter. The research results analysed in the previous chapter were also discussed in this chapter. Moreover, future research needs to address the limitations of this research. The human mindset can be changed through awareness and knowledge. To create awareness and knowledge, the inclusion of a sustainability unit in the curricula of educational institutes is very crucial. It is time to adopt sustainability strategies otherwise before it is too late. It must start from today; not from today but from now.

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Sustainability Awareness in Saudi Arabia

Leenah Al Sabban and Tomayess Issa

Abstract The individuals' impact on the environment has caused a need to study and evaluate why these humans act in non-sustainable ways. Nowadays, many researchers study how to change these non-sustainable behaviors. Colleges and universities (higher education sector) have been called on to increase awareness and knowledge of environmental problems in order to change these non-sustainable actions. This study has been done in Saudi Arabia. Saudi Arabia is a semi-developed country that has a low level of sustainable development awareness. The researchers have reviewed several articles describing such awareness initiatives. However, few studies have been done in Saudi Arabia. The purpose of this study is to examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector. An online survey was created, and one hundred and ten participants completed the survey questions, and the researchers analyzed the results to reach the research objective. The results of the online survey showed that the Saudis believe that sustainable development can increase their job advantages, and reduce their carbon footprint, gas emissions and pollution. Furthermore, some Saudis believe that some organizations and businesses will be damaged if they did not implement the sustainable development. Thus, this study's findings support further sustainability research, which is needed to see other apparent causes of the low level of sustainability awareness in Saudi Arabia. In addition, the researchers have proposed a number of sustainability advantages and disadvantages factors. Finally, there are number of limitations to this research. First, the participants were restricted to Saudis from a higher education sector. Second, most of the survey participants did not complete their surveys. Third, the survey participants took a long time to respond which is time-consuming to the researchers. Indeed, further suggestions and recommendations were delivered at the end of the research.

Keywords Sustainability · Awareness · Saudi Arabia

L. Al Sabban (✉) · T. Issa
School of Management, Curtin University, Perth, WA, Australia
e-mail: l.alsabban@postgrad.curtin.edu.au

T. Issa
e-mail: Tomayess.Issa@cbs.curtin.edu.au

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1 Introduction

In the last 25 years, the world has realized the devastating effects of the industrial revolution. Some of these problems include air pollution from energy production, high natural resources consumption, and transportation. This causes global warming, acid rain, and ozone depletion. Nowadays, the world leaders and governments have recognized these environmental problems are linked to economic development issues that are going to affect the future generations negatively.

Consequently, the concept of sustainable development has become the major goal for most businesses. There are many definitions of sustainable development. First, sustainability could be defined as economic development or as an ability or capacity which meets the present generation's needs without compromising the ability of the next generations to meet their own needs (Hopkins et al. 2009). Second, it has been established as development encompassing three main dimensions, which are economic, social, and environmental. Also, it is a common and important term currently used worldwide (Lele 1991).

Saudi Arabia is an important country because it has a high level of international petroleum production. So, sustainable development practices are a major consideration among private and public sectors in Saudi Arabia (Hashmi et al. 2015). Saudi Arabia contributes to sustainable development through its enterprise operations, governmental regulations, human rights, education, etc. On the other hand, there are many issues caused by different organizations or uneducated individuals due to their low level of sustainability awareness, which can affect the country's sustainable development. As sustainable development has become very essential these days, the main objective of this dissertation is to examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector.

In brief, this study will define the sustainable development concept, provide a brief history of the concept, and discuss its different goals. It will also examine and explore the current progress level towards sustainable development and identify the advantages and disadvantages of sustainability awareness in Saudi Arabia. In addition, the findings of this project can inform Saudi Arabian leadership or policymakers of the universities (higher education) to increase their student, staff, and faculty sustainability awareness and to achieve the country's sustainability goals in the future.

2 What Is Sustainability?

The word sustainability has become very popular in many different research studies such as policy-oriented research in terms of what public policies should achieve. This research paper will focus on the general definition of sustainability. Sustainability is an inspiration originated from the Brundtland Report of 1987 (Kuhlman and Farrington 2010). Moreover, one of the sustainability pathways is sustainable development. The Brundtland Report of the World Commission on Environment and Development defined sustainability or sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Kohn et al. 2010, 286). Sustainability is one of the newest subjects that tries to connect civic engineering with social science and environmental science with future technology. Furthermore, sustainability is concerned with the future generations' well-being and access to irreplaceable and rare natural resources (Kuhlman and Farrington 2010).

The term sustainability is very broad and a complex discipline. There are many researchers attempting to define the sustainability concept. Kuhlman and Farrington (2010) defined sustainability as a relationship between mankind moving towards a better life and the limitation forced by the nature. Mainly, there are three dimensions under the concept of sustainability, which are environmental, economic and social. Moreover, Matthew Mason defined sustainability as the study of how natural systems work, stay diverse and produce everything required for the ecology to stay in balance. In brief, sustainability looks to safeguard our health, both human and natural environment (Mason 2017). Sheehan (2009), and Mason (2017) stated that sustainable development or sustainability concentrates on balancing competing requirements: society requirements to move forward economically and technologically, and all other requirements which protect our environments.

However, sustainability is not just about the environment. Running a successful and sustainable development involves three factors which are: environmental and energy stewardship; organizational stewardship and human resources; and reaching financial and operational goals and objectives (Sheehan 2009). Despite the various definitions of sustainability, there are three major principles or dimensions that will be discuss in detail in the following section.

2.1 Environmental Sustainability

The environmental sustainability concept is the ability to maintain qualities and things which are valued in the physical environment. For instance, people want to maintain (Sutton 2004):

- the different capabilities by which the natural environment sustains the people's living conditions, such as clean air and water and a suitable climate,
- human life,
- environmental aspects which produce renewable resources (e.g. water, solar energy, fish, timber),
- life quality for all people, beauty and liveability of the environment.

This dimension (Environmental Sustainability) concerns environmental problems and solutions. In our world, there are many different environmental problems that people should be worried about including threats to water resources, climate change, high energy usage, and high population level (White 2009). To reduce these environmental problems now and in the future, people have to protect their environment by reducing power consumption, recycling, and using all resources at a sustainable rate (Mason 2017). Another solution is that the businesses should be regulated and controlled to prevent pollution and to keep carbon emission levels low. It is important to install renewable power sources in our businesses and homes (Mason 2017).

2.2 Economic Sustainability

Economic sustainability refers to the ability to support a defined economic production level for an unspecific period (indefinitely). It is the most elusive element of the triple bottom line approach (Doane and Macgillivray 2001) which will be discussed in detail in the coming sections. This dimension concentrates on how the businesses and organizations should be focused on profits, efficiency, and the influence of production processes and resources extractions (Coca-Prados 2013). So, most of the businesses should manage their economic performance in an efficient and effective way to stay in a sustainable position.

Moreover, the businesses' managers must be aware of production costs, and consumer costs in their businesses. Production costs come from labor, manufacturing, energy and maintenance costs. Consumer costs include purchase prices, usage costs, maintenance costs and energy costs (Neugebauer et al. 2015). For that reason, there are different tested, affordable, available and accepted management systems and tools for use by the developing 'economic sustainability Manager' (Doane and Macgillivray 2001).

2.3 Social Sustainability

The most important part of the third dimension is the society. There are various social issues that are affecting the level of social sustainability. These issues are related to fair wages, society health (including health effects on consumers, communities and workers), working conditions (including working hours and labor laws), human rights, safety (i.e. workplace safety) and education (i.e. literacy rate, university degrees, etc.) (Neugebauer et al. 2015). It is essential for every government and business manager to discover different ways to provide good levels of education to society, provide basic requirements and needs, improve working conditions, take care of their health, etc. These activities concentrate on sustaining beneficial relationships with community, customers and the employees as well as they have benefits in terms of positive consumer and profile and community support (Manufacturing Skills Australia 2017).

Sustainability and sustainable development are notions that have appeared in many facets of life whether it has been through books, internet, television shows, social media or newspapers. The human impact on the environment in terms of deforestation, natural resources depletion, overconsumption, pollution and possible climate changes has caused the global community to create large sustainability awareness campaigns and environmental policy changes (Hutcherson 2013). These awareness campaigns and environmental policy changes are essential to reach effective sustainable development and to avoid negative impacts on the environment. These negative impacts cause various issues which can damage world environments, natural resources and population in the long-term because the earth's resources are limited and could not support the future generations. Awareness and conservation must be concerned whenever people use the earth's natural resources. In that context, sustainable development has become essential for most countries. Many governments have established rules, regulations, policies and practices regarding the use of the country's resources. Rogers and Hudson (2011) stated that several organizations, both universities and businesses, are being responsible by changing rules and practices to meet the future environmental challenges.

Sustainable development is about protecting and keeping our planet and its natural resources for a long time. In brief, it is an effective plan which usually helps in resolving several environmental issues that may occur. Lele (1991), Kuhlman and Farrington (2010) discussed the three major pillars of sustainable development which they must balance when planning activities. These pillars are economic, social and environmental. In the last 25 years, the world has realized the devastating effects of the industrial revolution. Some of these problems include air pollution from energy production, high natural resources consumption, and transportation. This causes global warming, acid rain, and ozone depletion. Nowadays, the world leaders and governments have recognized these environmental problems are linked to economic development issues that are going to affect the future generations negatively. Consequently, the concept of sustainable development has become the major goal for most businesses. There are many definitions of sustainable development. First, sustainability could be defined as economic development or as an ability or capacity which meets the present generation's needs without compromising the ability of the next generations to meet their own needs (Hopkins et al. 2009). Second, it has been established as development encompassing three main dimensions, which are economic, social, and environmental. Also, it is a common and important term currently used worldwide (Lele 1991).

3 Corporate Social Responsibility (CSR)

Many consumers are aware of environmental challenges and the ethical operations of different organizations, and these consumers expect organizations to perform as good corporate citizens. In that context, organizations have been addressing their consumer requirements in the Corporate Social Responsibility form (Albus and Ro 2017). Corporate social responsibility is a business approach which is strongly linked to the businesses' sustainable development by delivering environmental, economic and social benefits for all the businesses' stakeholders. Additionally, CSR refers to an organization's voluntary activities such as adoption of human resource management practices, supporting local businesses and communities, and reducing environmental hazards (Barnett 2007; McWilliams and Siegel 2001). CSR is a crucial component of strategic planning and business models in organizations that aim to be competitive (Franklin 2008).

3.1 The Benefits of Corporate Social Responsibility

Corporate Social Responsibility positively affects several areas of an organization's competitiveness. Sen et al. (2006), and Forte (2013) clarified that most of the businesses' stakeholders who are aware of their organization's CSR initiatives usually exhibit many positive concepts and various benefits such as increase the organization's investment, maximize the organization's profit, benefit their communities by providing them with different activities, increase sales volume, enhance financial performance, enhance organization's reputation, and endorse organization's long-term profits, than the other persons who are unaware of the CSR significance. In addition, CSR usually improves relationships between communities as it aims to benefit the organization's stakeholders as well as society (Sen et al. 2006). CSR enhances the business ethics inside the organization as well as among their business partners and their competitors (Forte 2013).

Corporate Social Responsibility (CSR) addresses five major dimensions: product and service quality, environmental challenges, diversity problems, employee relationships, and community relationships. Inoue and Lee (2011) examined the effect of acting on these five dimensions on the financial performance of several industries. They found that each CSR dimension has a different influence on both future and short-term profitability, but has a positive effect on the organization's financial performance (Dwyer et al. 2009; Lee and Park 2009). Likewise, Luo and Bhattacharya (2006) stated that CSR practices have a great and positive impact on customer satisfaction and consequently on an organization's market value.

3.2 Types of Corporate Social Responsibility

The major idea behind Corporate Social Responsibility (CSR) is that organizations have several responsibilities to sustain. These responsibilities start from the lower-level responsibilities which can meet the basic business needs (making business profits), up to higher level responsibilities which support and benefit society as whole (benefiting society). Scilly (2016) has categorized Corporate Social Responsibility into four types:

Economic Responsibilities: a basic business responsibility. Every business exists to generate profits for its stakeholders. If the business fails, it will not be able to pay for business taxes, employees' wages and many other obligations (Scilly 2016).

Legal Responsibilities: as a foundation of Corporate Social Responsibility, it is crucial for every business to follow industry laws and regulations. This is important to the business by generating more profit as well as to benefit society by adhering to tax and labor laws (Bisk 2015).

Ethical Responsibilities: this type of responsibility should be examined once an organization is profitable and meets its industry laws and regulations (legal responsibilities). Activities that meet this responsibility might include providing for employees welfare and better benefits, providing jobs to individuals who have difficulty finding jobs, or paying higher wages. (Scilly 2016).

Philanthropic Responsibilities: the organizations should consider this responsibility type once they meet their economic, legal and ethical responsibilities. CSR ranges in scope, and can involve everything from building elderly hospital to donating time to a charity (Bisk 2015).

3.3 Roles of Corporate Social Responsibility

All business stakeholders and all the individuals in any organizations must be involved in the CSR plan. Every individual in the organization has a CSR role. These roles are (Rangan et al. 2012):

- Corporate responsibilities to the investors or business' stakeholders are the business must disclose all important and necessary information to investors and stakeholders, respect them, provide them a high level of security, and protect the confidentiality of corporate information.
- Corporate responsibilities to the business' managers and directors are improve corporate managing systems, and periodically provide an accurate corporate financial report.
- Corporate responsibilities to the business' employees are provide them with welfare and security as stated in the labor protection laws, pay their wages, and improve their skills by offering training programs or workshops.
- Corporate responsibilities to consumers are provide high quality products and services, provide sufficient information about the business and its products and services, and respond quickly to their enquiries and complaints.
- Corporate responsibilities to the business' partners are provide good offers and fair contracts, and do not accept any types of bribery or corruption.
- Corporate responsibilities to the environment and society are set rules, regulations and practices to protect the environment, gain more knowledge about the local culture, help and support local workers and society as whole.
- Corporate responsibilities to the business' competitors are engage in and encourage fair competition.

CSR can take many different forms based on the type of the organization, business, culture, or traditions in different countries (Sen et al. 2006).

3.4 Advantages and Disadvantages of Corporate Social Responsibility

The advantages of CSR can be obtained by applying its policies and practices. The rewards and advantages gained from CSR motivates and encourages businesses or organizations to commit to its activities (Swanson 1995).

Swanson (1995), and Forte (2013) reported the advantages of CSR are that it: improves an organization's profit and encourages long-term profit, increases returns on investments, enhances an organization's image, improves an organization's reputation, increases employee retention and attraction, raises sales volumes, and attracts new investors from several sources. Dedication and commitment to CSR improves stakeholder relationships and community relations as whole. Forte (2013) stated that CSR contributes to a satisfactory public image. Public image is a significant element in the organization's success. Furthermore, organizations, which adopt CSR, can support a healthy environment, a better quality of life, and a friendly community (Maignan et al. 1999).

4 Sustainability in Developing Countries

A developing country refers to a poor, agricultural country that is looking to be more advanced socially and economically. Also, it is a term given to the underdeveloped or less developed countries compared with other countries worldwide. Due to the poor understanding of sustainable development and its impact in the developing countries, there are several significant projects, particularly those in the sanitation and water sector, that fail to bring benefits to society over a long period (Carter et al. 1999). These developing countries usually depend on assistance and support from developed countries and they implement the developed countries' management concepts and philosophies (Punnett 2013). There are 139 countries that are listed in the United Nations Statics Divisions as developing countries around the world. Examples of these countries are: Ghana, Eritrea, Niger, Mali, Pakistan, Indonesia, Mexico, Cuba, Brazil, Libya, Algeria, Afghanistan (UNSD 2015).

The developing countries can be recognized by a number of characteristics: (1) general poverty disrupting every aspect of life, (2) lack of businesses and industries, (3) lack of capital and technology, (4) lack of basic infrastructure, (5) over-population, (6) a high level of unemployment, (7) low levels of education, (8) lack of basic services such as health services, (9) dependence on agriculture as a main source of income, and (10) underutilizing the countries' natural resources (Jeevan 2010).

Punnett (2013) states that developing countries need to develop basic infrastructure such as transport infrastructure, education levels and standards, improve industries, businesses and basic services, utilize their natural resources beside their agriculture sources, to improve their life-style and to follow the track of developed countries.

As Cobbinah et al. (2011) indicate sustainable development can balance the economic, social and environmental dimensions both currently and in the future. Also, sustainable development can protect and improve economic and social environments, ensure equality between societies, reduce the poverty percentage, and seek to resolve various economic, social or environmental conflicts. Thus, sustainability and sustainable development can help developing countries tackle challenges or issues that they may face in present or in the future (Adenle et al. 2013). Furthermore, different programs in the United Nations (UN) such as the UN Environment Program as well as the UN Human Settlements Program aim to support developing countries to engage in sustainable development (Cobbinah et al. 2011). Nevertheless, it is quite hard for some developing countries to begin sustainable development due to the lack of plans and strategies as well as the absence of human capital to support new and imported technologies (Alkire and Santos 2010).

5 Sustainable Development Advantages

In order to thrive for future generations, societies must know how to balance environmental, social and economic concerns. Mainly, sustainability is about having the proper interaction and balance between the following (Weybrecht 2010):

- **Social Equity (People)** e.g.: human rights, gender equality, people security, justice, and cultural diversity).
- **Environmental Protection (Planet)** e.g.: agriculture, energy, water, forests, deserts, air and fish.
- **Economic Development (Profit)** e.g.: economic growth and limits, waste management, education, employment, corporate responsibility and poverty reduction.

As Weybrecht (2010) stated, creating an appropriate balance between the three elements, and adopting sustainability in businesses, will generate many advantages to these businesses. First, it can reduce business costs because sustainability offers the mechanism to reduce costs by concentrating on using fewer resources such as energy, people, raw materials or water. Also, sustainability drives businesses to make their processes more efficient and eliminate or reduce waste. Second, it can preserve raw materials and resources. Sustainable development can differentiate businesses, maximize business income, attract new customers, and increase market share. Third, sustainable development can attract quality employees, satisfy consumer needs, meet stakeholder expectations, attract capital investment, capitalize on new advantages, enhance corporate social responsibility, enhance human rights and community investment, minimize business risk management, etc. (Pearce et al. 2013; Weybrecht 2010). Finally, there are several environmental advantages. Sustainability can decrease carbon footprints and emissions, reduce pollution as well as reduce health hazards (Weybrecht 2010).

6 Sustainable Development Disadvantages

Several disadvantages are associated with sustainability adoption in businesses. These disadvantages normally affect the business' performance and business' cost. First, it is more expensive to create services and products in a sustainable environment than in a non-sustainable manner. Second, sustainable development usually maximizes businesses' interest rates, can increase competition between businesses, and the cost of sustainable raw materials can be higher (Weybrecht 2010). In addition, adoption of sustainability in businesses will encourage governments to generate new environmental and economic regulations.

In fact, it can be very difficult to start a company with sustainable development in a developing country due to issues such as transportation or resource limitations, which can cause the company's downfall (Robberts 2016).

Moreover, another disadvantage to sustainable development is increased business fraud, governance failure and compliance breaches. Also, sustainability can maximize the business's transaction and system failure. Other disadvantages of sustainability adoption are: increased chance of marketing failure, supply chain crises as well as it can increase business's scandals (Weybrecht 2010).

7 Sustainability in Saudi Arabia

The Saudi government and many public and private institutions are becoming aware of sustainable development. Several Saudi sectors have applied Corporate Social Responsibility (CSR) and sustainable development in their corporations.

Belloumi and Alshehry (2015) have reviewed Saudi Arabian sustainable energy development. They have also studied the role of Saudi energy consumption in economic growth from 1971 to 2012 by using specific procedures and principles such as the autoregressive distributed lag cointegration technique and energy-led growth hypothesis to examine the relationship between real Gross Domestic Product (GDP) and energy consumption, human capital, and employment.

The result of their study shows the importance of energy utilization on many different economic activities through several production, investment and consumption channels in Saudi Arabia. Moreover, Belloumi and Alshehry (2015) confirm that energy is not neutral to economic growth, but the relationship between them is very important. This can help decision makers make the best energy management decisions, which are crucial in responding to climate change and the environment. They also mention the importance of energy efficiency and the investment in renewable energy resources such as wind and solar because these can save more money, reduce the business' carbon footprint, and decrease greenhouse gas emissions to meet the global commitment on climate change (Belloumi and Alshehry 2015). Utilization of natural renewable energy resources in Saudi Arabia will provide a healthy environment for long-term sustainable development (Elhadidy and Shaahid 2009). All these activities can lead Saudi Arabia to a great future with sustainable development.

Saudi Arabia has a plan and vision for sustainable development in 2030. This vision is based on two pillars. The first pillar is the Saudi determination to be a global investment capital. The second one is transforming the unique location of Saudi Arabia into an international hub connecting three continents, Africa, Europe and Asia (Alarabiya 2017).

As Saudi Arabia is very rich in its natural resources, it can depend on different resources for energy needs. There are different objectives under the 2030 vision: Saudi government will convert the public investment fund into the largest wealth fund worldwide, it will encourage its major organizations and businesses to expand and take their place in different markets globally, save the country's resources, and create more job advantages for Saudi's citizens (Hassan 2016).

The three themes behind the Saudi 2030 vision are: a vibrant Saudi society, an ambitious nation, and a flourishing economy. Moreover, there are several goals behind these themes, which are: having a healthy society, reaching environmental sustainability, offering equal advantages, increasing the Saudi investment capabilities, developing a great business environment, and maximizing the energy sector competitiveness (Alarabiya 2017; Hassan 2016).

8 Research Methodology and Research Question

The primary focus of this research is to consider sustainability awareness in Saudi Arabia. More specifically, this research investigates the different advantages and disadvantages of the Saudis' attitude toward sustainability. In order to work within the context described above, this research question for this chapter is as follow: "What are the advantages and disadvantages of sustainability awareness in Saudi Arabia? "The research method is the process that the researchers use to gather and analyze data, information and knowledge for various purposes such as making a business or a management decision. In principle, there are two research methods that can be utilized in research: a quantitative, a qualitative, or, in some cases, a mixture of the two.

8.1 Qualitative Research Methods

Qualitative research is frequently associated with an interpretive philosophy (Denzin and Lincoln 1994). Various techniques are used in qualitative research to collect and analyze the data as well as to produce accurate conclusions; they include in-depth interviews, case studies, etc. (Saunders et al. 2012). These techniques provide comprehensive understanding and insight for specific research phenomena. The presentation of the research results and conclusions are delivered as detailed descriptions, not in statistical format, which helps the researcher gain enough understanding of the participants' perspectives, experiences, etc.

8.2 Quantitative Research Methods

The quantitative method emphasizes the mathematical, numerical, and/or statistical analyses of collected data through various techniques such as surveys, questionnaires, etc. Quantitative research is often associated with the deductive research approach by using collected data to test the proposed theory. At times, it is associated with the inductive approach, where collected data are utilized to evolve the theory (Saunders 2016). This method concentrates on fact findings to achieve a quantitative conclusion, which should be supported by statistical and numerical indications (Saunders et al. 2012).

In the process of choosing a research methodology that suits the research, the researcher should identify the kind of data required to answer the research question. The purpose of this research project is to examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector as well as the related risks and opportunities when businesses adopt sustainable development. This requires appropriate investigation and analysis to deliver the research outcome. So, the study was concerned with gathering data that provides enough understanding and frequency of the phenomena, and in order to do so, a quantitative research methodology was adopted for this research.

8.3 The Chosen Research Method and Approach

In the process of choosing a research methodology that suits the research, the researcher should identify the kind of data required to answer the research question. The purpose of this research project is to examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector as well as the related disadvantages and advantages when businesses adopt sustainable development. This requires appropriate investigation and analysis to deliver the research outcome. So, the study was concerned with gathering data that provides enough understanding and frequency of the phenomena, and in order to do so, a quantitative research methodology was adopted for this research.

The current research will be conducted using a deductive research design. A deductive research approach is usually associated with quantitative research where the researcher can concentrate on using quantitative data to test a specific theory (Saunders 2016). After testing the theories in question, reliable results can then be produced, and research conclusions are drawn clearly (Saunders et al. 2012). Eventually, the research outcomes will be delivered as quantitative data, statistical analyses, and/or mathematical calculations (Trochim and Donnelly 2001). In brief, the research outcomes will have more information across many cases.

8.4 Research Design

This section talks about the research processes details (design), which includes the survey design, unit of analysis, and target sample and population. The main objective of this research is to examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector as well as the related disadvantages and advantages when businesses adopt sustainable development.

8.5 Unit of Analysis

The unit of analysis is the main entity, which is being evaluated, studied and analyzed in a research or study. The unit refers to 'who' or 'what' that is being analyzed or studied such as groups, individuals, social interactions (i.e. divorces, arrests, or dyadic relationships), artifacts (i.e. newspapers, books, magazines, or photos), and geographical units (i.e. state, country, or town). In terms of this research, the unit of analysis is a group of people in Saudi Arabia to test their sustainability awareness level. Moreover, the survey constructed for this study uses the Likert scale approach to scale the Saudi participants' response towards sustainable development in Saudi Arabia. Also, it evaluates the Saudis' attitudes towards sustainability adoption by businesses. The survey's Likert scale includes five points which are: strongly agree, agree, neutral, disagree, and strongly disagree.

8.6 Target Population and Target Sample

When the study is looking at more than one case, the sample in this research design may be one or more locations, one or more businesses, one or more individuals, or one or more occasions (Bryman and Bell 2015). One of the difficulties faced when conducting this research was the lengthy approval processes that the researcher needed to distribute the survey to certain groups in order to gather the required data. It is much better to have a big research sample, which will increase the accuracy of the research result as well as to minimize the error possibility that could exist (Burns 2000). Thus, for this research project, the researcher aimed to fill a reasonable number of the online surveys by Saudi participants within specific time constraints. In brief, the target population for this research is a group of Saudi individuals from different sectors (both educational and professional sectors).

8.7 Data Collection

This section discusses the data collection methods (web-based survey) and the design of the research questions, and then covers all stages of the data collection process, this research data was collected through Qualtrics, which is a free online application. Qualtrics provides the researcher with an easy to use and clear survey platform. The sustainability awareness online survey was distributed to 276 Saudi participants through various methods, as follows:

- Social network (i.e. Facebook),
- Smartphone application (i.e. WhatsApp, Text Messages),
- Email,
- Dar AL-Hekma University Community (DAH) community, after getting the DAH Ethics Research Department Approval.

8.8 Data Analysis

After the surveys were returned, the data and information were transcribed. The data were collected through Qualtrics online software as discussed in the previous (data collection) section.

Data analytic is another term for the data analysis, which refers to the process of applying logical and statistical tools to define, explain, clean, model and transform data with the goal of having useful results and conclusions (Galetto 2017). Several issues could be faced during this phase i.e. non-compliance data or missing data. However, the process of data analysis helps the researcher to present the research result in an easy, clear and understandable format (Haeffele et al. 2014). As this research relied on a quantitative method, the research results are analyzed and presented in numerical format. In addition, the researcher has used specific software to analyze the collected data, which is the Statistical Package for the Social Sciences (SPSS) version 24.0.

8.9 Reliability and Validity

As this study utilized quantitative data only, reliability and validity will be discussed within the context of the philosophical and methodological approaches to this research. Reliability is a significant concept which is related to evaluating the research quality. It is commonly concerned with collected data accuracy and consistency (Gratton and Jones 2004). Similarly, several researchers such as Lacey and Luff (2001), and Gratton and Jones (2004) stated that when researchers think of the validity concept, they should consider the right method for their research to ensure that they are measuring what they want to measure as well as to ensure the research outcome is valid. (Lacey and Luff 2001).

In the context of reliability, this study used specific research tools and techniques to preserve the consistency of the collected data, and to minimize subject bias and research errors throughout this study. For instance, the researcher did not force participants to choose specific answers in the research. Also, the researcher told the participants that there are no right or wrong answers (Rubin and Babbie 2011). Therefore, these features assisted the researcher to ensure that reality has matched the research results and findings. Additionally, any reliable research should use a high-quality instrument. There are various instruments that are used worldwide, but for the purpose of this research, the Qualtrics survey instrument was used (Kumar 2011). In terms of validity, several categories of validity can be used in a quantitative research. The first is content validity, which is also known as textbook validity, logical validity or course validity. Content validity should cover all the content related to the research's observations to ensure that the research findings are valid (Heale and Twycross 2015). Second is construct validity, which is the development of related measurement and knowledge of the research construction (Kumar 2011). Third is predictive validity, which focuses on the instrument ability to check and predict the research's outcomes.

9 Study Results

The research questions in the online survey were created to reach the research objectives and gain more information about sustainability awareness in Saudi Arabia especially in the higher education sector. The online survey gathered various data from its respondents such as the participants' gender, their ages, the field of their studies and education levels, their daily internet usage, the types of devices used, and their perspectives about sustainability disadvantages and advantages. The researcher distributed the online survey to approximately 276 Saudi participants, but only 110 participants completed the full survey. The response rate of the online survey is 39.86%. Most of the participants were females by approximately 66.4% and only 33.6% were male.

The survey participants were between 25 years to 30 years of age. There were no participants under the age of 17, and there were no participants over 40 years old. Most of the participants were from the higher education sector (see Table 1). Moreover, there were a variety of occupations amongst the survey respondents such as: accountants, lawyers, engineers, a prgrammer, a business manager, a researcher, a chemical engineer, a HR representative, a geologist, a PHD student, a system analyst, a geophysicist, a CSR manager, an inventory controller, a legal counsel, and others.

Table 2 shows most of the survey participants (22.7%) were from the science and engineering field of study. The percentage range for other fields of study is 3–10%.

Table 3 shows that most (38.2%) of the online participants graduated from university with a bachelor degree, and 33.6% had a master's degree in different fields of study as discussed earlier. Also, there were 7.3% of the participants with a Ph.D.

There are different types of devices used by Saudi users while they are working or accessing the internet. This survey question allows every user to choose more than one option. The survey results show that the majority (89.22%) of Saudi users surveyed are accessing the internet through their smartphones (Table 4).

The following table (Table 5) illustrates that most of the Saudi users were introduced to the concept of Sustainability and Green Information Technology in their higher education (52.3%). Other users learned the concept from the internet (36%), their schools (21.6%), books, magazines, conferences and others.

A question in the online survey asks participants about the device brand they use. The majority (60.9%) of respondents are using Apple devices. The rest are divided between Dell, IBM, Google, and other (Table 6).

The Table 7 illustrates the number of Saudi participants who read the sustainability reports of a product before purchase. The survey has shown that most of the respondents do not read the sustainability reports before buying their products.

Table 1 Range of the questionnaire participants' ages (prepared by the authors)

Age range	Frequency	Participants' percentage (%)
17 years and under	0	0
18–20	13	11.8
21–24	21	19.1
25–30	42	38.2
31–35	19	17.3
36–40	15	13.6
41–45	0	0
46–50	0	0
51–55	0	0
56–60	0	0
61–65	0	0
Over 65	0	0
Total	110	100

Table 2 Participants' study fields (prepared by the authors)

The study fields	Frequency	Participants' percentage (%)
Accounting	10	9.1
Business law	9	8.2
Economics and Finance	4	3.6
Information systems	9	8.2
Information technology	4	3.6
Computer science	7	6.4
Management	10	9.1
Marketing	3	2.7
Health sciences	7	6.4
Humanities	2	1.8
Science and engineering	25	22.7
Art and design	4	3.6
Others	16	14.6
Total	110	100

Table 3 Questionnaire participants' education level (prepared by the authors)

Student status	Frequency	Participants' percentage (%)
Primary education	2	1.8
Higher secondary/pre-university	5	4.5
Professional certificate	4	3.6
Diploma	4	3.6
Advances/higher/graduate diploma	0	0
Bachelor's degree	42	38.2
Post graduate diploma	4	3.6
Master's degree	37	33.6
Ph.D.	8	7.3
Others	4	3.6
Total	110	100

Table 8 shows that most of the Saudi users change their devices every eighteen months to two years.

The online survey results show that around 66% of Saudi users change their devices for better functionality, 48% of the users want to keep up with technology, and other reasons such as size and speed (see Table 9).

The online survey results illustrate the low level of sustainability awareness in Saudi Arabia. Only 41% of the survey participants believe that frequent device

Table 4 Types of devices used by Saudi users (prepared by the authors)

Device types	Frequency	Participants' percentage (%)
PC	26	23.4
Desktop	28	25.2
Laptop	81	73
Netbook	5	4.5
PDAs	0	0
Workstation	7	6.3
Tablet	29	26.1
Smartphone	99	89.2
Others	2	1.8

Table 5 Level at which sustainability was introduced to participants (prepared by the author)

Level	Frequency	Participants' percentage (%)
School	24	21.6
Higher education	58	52.3
Internet	40	36
Books	6	5.4
Magazine	9	8.1
News media	26	23.4
Conferences	21	18.9
Others	6	5.4

Table 6 Participants' device brand (prepared by the authors)

Participants' device brand	Frequency	Participants' percentage (%)
Apple	67	60.9
Google	21	19.1
Dell	9	8.2
IBM	2	1.8
Others	11	10

Table 7 Percentage of participants who read the sustainability Reports (prepared by the authors)

Do you read the company sustainability reports?	Frequency	Participants' percentage (%)
Yes	14	12.7
No	63	57.3
Maybe	24	21.8
Not at all	9	8.2

Table 8 Frequency of device changes by Saudi users (prepared by the authors)

Frequency of device changes	Frequency	Participants' percentage (%)
Every 6 months	0	0
Every 12 months	18	16.4
Every 18 months	21	19.1
Every 24 months	34	30.9
Every 30 months	9	8.2
Every 36 months	13	11.8
Every 42 months	9	8.2
Others	6	5.5

Table 9 Reasons behind device changes by Saudi users (prepared by the authors)

Reasons behind device changes	Frequency	Participants' percentage (%)
Size	22	19.8
Speed	48	43.2
Functionality	73	65.8
Keeping with technology	53	47.7
Other	4	3.6

changes will cause damage to the planet. On the other hand, 48% of the Saudi participants are unsure about its impact on the planet (see Table 10).

As it shows in Table 11, most of the Saudi users believe that awareness and social networking (82.9% and 71.2% respectively) can change designers' and users' mindsets regarding sustainability.

The data reliability usually presents in a table of Cronbach's Alpha. As the researcher used the Likert-type scales in the online survey questions to analyze the data reliability and the survey internal consistency, it is imperative to interpret, calculate and report Cronbach's Alpha (Gliem and Gliem 2003). Cronbach's Alpha is a common test for the researcher to test the accuracy and validity level in the online survey questions.

Table 10 Percentage of Saudi users who believe that frequent device changing will cause damage to the planet (prepared by the authors)

Do you think changing your device frequently will have a negative impact to the planet?	Frequency	Participants' Percentage (%)
Yes	45	40.9
No	12	10.8
Maybe	53	47.7
Not at all	0	0

Table 11 Proposed ways to change the mindset of users and designers regarding Sustainability (prepared by the authors)

Proposed ways to change the users' and designers' mindset regarding sustainability	Frequency	Participants' percentage (%)
Training	35	31.5
Education	62	55.9
Awareness	92	82.9
Workshop	32	28.8
Internet	44	39.6
T.V.	33	29.7
Social networking	79	71.2
Others	0	0

(George and Mallery 2003)

George and Mallery (2003, 231) provide the following rules of thumb:

– >0.9—Excellent,
– >0.8—Good,
– >0.7—Acceptable,
– >0.6—Questionable,
– >0.5—Poor, and
– <0.5—Unacceptable.

In this research, the researcher is testing the sustainability advantages and disadvantages in Saudi Arabia. The data reliability results are 0.918 for advantages (see Table 12), and 0.951 for disadvantages (Table 22). Both results are in an excellent range according to George and Mallery's rule (see Table 13).

Prior to the factors' extraction, there are many tests that should be done to evaluate the respondent data on sustainability for factor analysis. One of these tests is Kaiser-Meyer-Olkin (KMO) and Bartlett's Test. Usually the KMO index provides a value from zero to one. The KMO index ranges should be (0.5) or more to consider it

Table 12 Advantages' Cronbach's alpha (prepared by the authors)

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on standardized items	*N* of items
0.918	0.917	24

Table 13 Disadvantages' Cronbach's alpha (prepared by the authors)

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on standardized items	*N* of items
0.951	0.947	13

suitable for factor analysis. The significance of the Bartlett's Test for Sphericity should be (Sig. <0.05) to be suitable for factor analysis (Williams et al. 2010). These two tests should be used by the researcher to assess the research data and prepare them for the factor analysis.

Index ranges for KMO (Fidel 2000, 647)

- Value range between (0.5–0.7) = Mediocre
- Value range between (0.7–0.8) = Good
- Value range between (0.8–0.9) = Great
- Value range >0.9 = Superb

As seen in Table 14, the result of the Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the advantages is equal to 0.819, which is mean that the respondent data are suitable and adequate for the factor analysis. Furthermore, the significance results for the Bartlett's Test of Sphericity is equal to 0.000, which is mean that the variables' correlation is sufficient and significant because it is less than 0.05.

As seen in Table 15, the result of Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the disadvantages is equal to 0.934, which is mean that the respondent data are suitable and adequate for the factor analysis. Furthermore, the significance results for the Bartlett's Test of Sphericity are equal to 0.000, which means that the variables' correlation is useful, sufficient and significant because it is less than 0.05.

Factor analysis is a multivariate and common statistical approach, which is usually used for combining a number of correlated variables under one or more specific factors (Fidel 2000). These variables usually have a high correlation between each other. Other variables could have low correlation and not related to each other. Factor analysis is a very important technique that is commonly used in many fields such as Education, Social Science, Psychology, Information Systems and Technology, etc.

Table 14 KMO and Bartlett's test for the advantages (prepared by the authors)

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.819
Bartlett's test of sphericity	Approx. Chi-square	1443.742
	Df	276
	Sig.	0.000

Table 15 KMO and Bartlett's test for the disadvantages (prepared by the authors)

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.934
Bartlett's test of sphericity	Approx. Chi-square	1272.012
	Df	78
	Sig.	0.000

Also, it can be used in refinements, test evaluations, measures, scales, and developments. There are two types of factor analysis: confirmatory factor analysis (CFA), and exploratory factor analysis (EFA) (Gorsuch 2003). Nowadays, many researchers are using factor analysis techniques to examine the structure and the relationship between the variables.

There are several purposes of Exploratory Factor Analysis (EFA): reduce the variables' numbers, test the relationship and structure between variables, address the correlated variables and it is also used for theoretical construct development.

The Rotated Factor Matrix (see Table 16) produced three factors for advantages. There are nine variables for the first factor, five variables for the second factor, and four variables for the third factor. Starting with factor one, most of the values are between 0.630 and 0.760, which means that most of the Saudi users surveyed believe that the adoption of sustainability in an organization will improve human rights, satisfy customer needs, increase productivity, attract quality employees, reduce risk management, create new jobs, meet stakeholder expectations, improve community investment, and attract new advantages.

For the second factor, most of the values are greater than 0.620, which means that the respondents believe that the adoption of sustainability will reduce paper

Table 16 Advantages factor matrix (prepared by the authors)

Rotated Component Matrix			
	Component		
	1	2	3
Satisfy customer needs	0.758	0.290	−0.111
Attract quality employees	0.757		
Increase productivity	0.751	0.241	0.121
Reduce risk management	0.698	0.269	
Improve human rights	0.687	0.210	
Create new jobs	0.677	0.153	0.194
Improve community investments	0.660	0.220	0.247
Meet stakeholder expectations	0.655	0.171	
Attract new advantages	0.632	−0.124	0.249
Improve social responsibility investing	0.518	0.396	−0.137
Improve corporate social responsibility	0.515	0.412	
Increase triple bottom line – People, Planet and Profit	0.477	0.378	0.252
Enhance reputation	0.476	0.449	0.117
Differentiate businesses	0.429		0.310
Reduce paper usage		0.700	0.298
Increase cost-effectiveness	0.302	0.679	
Reduce consumption of raw materials		0.669	0.301
Increase efficiency	0.321	0.657	
Reduce energy and water usage	0.225	0.629	0.248
Reduce health hazards	0.104	0.529	0.190
Reduce carbon footprint		0.148	0.885
Reduce pollution		0.248	0.875
Reduce emissions		0.336	0.815
Increase green strategy	0.209	0.129	0.745
Extraction Method: Principal Component Analysis. **Rotation Method:** Varimax with Kaiser Normalization.			
a. Rotation converged in 7 iterations.			

Table 17 Factor one for research advantages (prepared by the authors)

Variable name	Factor loading	Label
Satisfy customer needs	0.758	New advantages
Attract quality employees	0.757	
Increase productivity	0.751	
Reduce risk management	0.698	
Improve human rights	0.687	
Create new jobs	0.677	
Improve community investments	0.660	
Meet stakeholder expectations	0.655	
Attract new advantages	0.632	

usage, increase cost-effectiveness, increase efficiency, reduce raw material consumption, and reduce energy and water usage. Finally, the values of the third factor are between 0.740 and 0.886, which means that the respondents believe that the adoption of sustainability will reduce carbon footprint, reduce pollution and emission, and increase green strategy.

Factor one includes customer satisfaction, human rights improvement, community investment improvements, attraction of quality employees, and the creation of new jobs. The researcher proposed the following name, New Advantages, for factor one variables as they provide advantages to organization, customers, stakeholders, and employees (see Table 17).

Factor two includes the five variables shown in Table 18. The researcher proposed the following name, Resources, for this factor because sustainability adoption will reduce resource consumptions.

Factor three includes the four variables shown in Table 30. The researcher proposed the following name, Green Environment, for this factor as sustainability adoption will reduce the pollution, carbon footprint, and emissions (see Table 19).

Table 18 Factor two for research advantages (prepared by the authors)

Variable name	Factor loading	Label
Reduce paper usage	0.700	Sustainable resources
Increase cost-effectiveness	0.679	
Reduce consumption of raw materials	0.669	
Increase efficiency	0.657	
Reduce energy and water usage	0.629	

Table 19 Factor three for research advantages (prepared by the authors)

Variable name	Factor loading	Label
Reduce carbon footprint	0.885	Green Environment
Reduce pollution	0.875	
Reduce emissions	0.815	
Increase green strategy	0.745	

Furthermore, the Rotated Factor Matrix (Table 20) produced two factors for disadvantages. There are ten variables for the first factor, and three variables for the second factor. The highest four values for the first factor are 0.918, 0.895, 0.886, and 0.879, which means that environmental irresponsibility can create and increase several failures. Furthermore, there are three variables in the second factor. The values of these variables are 0.751, 0.728, and 0.602, which discusses the adoption of sustainability disadvantages.

Factor one contains ten different variables as shown in Table 21. Some of these variables are: increased governance failure, increased transaction failure, increased scandals, etc. The researcher has named this factor Environmental Disadvantages because all the issues are related to the environment.

Table 20 Disadvantages' factor matrix (prepared by the authors)

Rotated Component Matrix		
	Component	
	1	2
Increase governance failure (including environmental actions and environmental compliance failures)	0.918	0.165
Increase transaction failure due to environmental liabilities	0.895	0.261
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	0.886	0.123
Increase fraud (including environmental actions and environmental compliance failures)	0.879	0.219
Increase scandals by perceived environmental irresponsibility	0.867	0.263
Increase security and systems failures caused by environmental problems	0.854	0.259
Increase marketing failure by perceived environmental irresponsibility	0.833	0.315
Increase supply chain crises due to suppliers' environmental problems	0.732	0.460
Increase insurance crises due to environmental disasters	0.667	0.413
Increase interest rates	0.610	0.358
Increase number of new regulations including environmental	0.158	0.751
Increase competition for and cost of raw materials	0.125	0.728
Inflate costs	0.469	0.602
Extraction Method: Principal Component Analysis.		
Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

Table 21 Factor one for research disadvantages (prepared by the authors)

Variable name	Factor loading	Label
Increase governance failure (including environmental actions and environmental compliance failures)	0.918	Environmental disadvantages
Increase transaction failure due to environmental liabilities	0.895	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	0.886	
Increase fraud (including environmental actions and environmental compliance failures)	0.879	
Increase scandals by perceived environmental irresponsibility	0.867	
Increase security and systems failures caused by environmental problems	0.854	
Increase marketing failure by perceived environmental irresponsibility	0.833	
Increase supply chain crises due to suppliers' environmental problems	0.732	
Increase insurance crises due to environmental disasters	0.667	
Increase interest rates	0.610	

Table 22 Factor two for research disadvantages (prepared by the authors)

Variable Name	Factor loading	Label
Increase number of new regulations including environmental	0.751	3Is
Increase competition for, and cost of, raw materials	0.728	
Inflate costs	0.602	

The researchers have named factor two as 3Is because it includes three disadvantages of sustainability adoption in an organization. These disadvantages are increased numbers of new regulation, increased competition for, and cost of, raw materials, and inflation in general costs (see Table 22).

10 Discussion and New Findings

Sustainability has become a popular concept meaning to preserve the earth's natural resources for future generations. Also, it is important for all people to save the earth's natural resources and to be aware of their future. In brief, sustainable development is about protecting our planet and its natural resources for a long time. It is an effective plan which usually helps in resolving several environmental issues. As Lele (1991), Kuhlman and Farrington (2010) stated the three major sustainable development pillars, economic, social and environmental, must have a balance between activities. Several issues, such as excessive resource consumption and deforestation, and waste generation, can affect the sustainable development balance.

Moreover, the United Nation has seventeen sustainable development goals in order to reach sustainability. These goals are: *No Poverty, Zero Hunger, Good Health and Well-Being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry, Innovation and Infrastructure, Reduce Inequalities, Sustainable Cities and Communities*, *Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace, Justice and Strong Institutions, and Partnership for the Goals* (United Nations 2016).

Furthermore, many countries are starting to put policies and regulations in place to conserve the environment and their natural resources as well as to reach a sustainable future. One of these countries is Saudi Arabia. Saudi Arabia is a semi-developed country, which has an oil-based economy and is the largest crude producer and exporter in the world. Some of the Saudi's natural resources are gold, petroleum, natural gas, copper and iron ore. Also, gas and oil make up ninety percent of the Saudi government income (NRGI 2013; RTCC 2012).

Thus, the researchers selected the topic of Sustainability Awareness in Saudi Arabia to determine the Saudi population's sustainability awareness level, and to examine the advantages and disadvantages of sustainability awareness in the Saudi Arabia. The study research question was: *What are the advantages and disadvantages of sustainability awareness in the Saudi Arabia?*

The main objective of this question was to investigate the advantages and disadvantages of sustainability awareness in Saudi Arabia, which may impact the Saudis' attitude toward sustainable development. In addition, the research objective was: *To examine the advantages and disadvantages of sustainability awareness in Saudi Arabia in the higher education sector.*

In order to answer the research question and reach the research objective, an online survey was created and distributed to Saudi participants to discover the key factors related to sustainability awareness in Saudi Arabia, to identify the Saudis' attitudes toward sustainability, and to recognize the advantages and disadvantages associated with implementing sustainable development. Additionally, the researcher aimed to find several measures to increase sustainability awareness in Saudi Arabia. An online survey was distributed to 276 Saudi participants, but only 110 respondents completed the online survey. Females made up 66.4% of respondents and 33.6% were males. Also, most of the respondents were between 25 years to 30 years of age, and there were no respondents under the age of 17. Furthermore, the majority of the participants were from the higher education sector and from different fields of study such as Science and Engineering, Information Technology, Accounting, Information Systems, etc.

The results showed that Saudi users spend up to five hours daily on their computers, and they spend five to ten hours on the internet for various purposes such as working, studying, shopping, and checking emails and social networking. The users usually access the internet via several devices, but they are using the smart phone the most because they can use it everywhere. The analysis results have shown that most of the Saudi users were introduced to the concepts of sustainable development and green information technology during their higher education by approximately 52.3%. The rest of the users learned these concepts from their schools, internet, books, magazines, media, and conferences. The survey revealed that most of the respondents do not read the products' sustainability reports before buying them. Moreover, only 41% of the survey participants believe that frequent device changes will cause damage to the planet. On the other hand, 48% of the Saudi participants were unsure about its impact on the planet. To solve this issue, the majority of respondents believed that raising awareness and social networking can change designers' and users' mindsets regarding sustainable development.

The researcher used the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sampling Adequacy for the research advantages and disadvantages. The advantages' value was equal to 0.819, and the disadvantages' value was equal to 0.934, which meant that the respondent data were suitable and acceptable for the factor analysis. Additionally, the significance results for the Bartlett's Test of Sphericity (for both advantages and disadvantages) were equal to 0.000, which meant that the variables' correlation was useful, appropriate and significant because it was less than 0.05. The researchers named three advantages' factors, and two disadvantages' factors:

Factors of Advantages:

- New Advantages included nine variables: satisfy customer needs, attract quality employees, increase productivity, reduce risk management, improve human rights, create new jobs, improve community investments, meet stakeholder expectations, and attract new advantages.
- Resources included five variables: reduce paper usage, increase cost-effectiveness, reduce consumption of raw materials, increase efficiency, and reduce energy and water usage.
- Green Environment included four variables: reduce carbon footprint, reduce pollution, reduce emissions, and increase green strategy.

Factors of Disadvantages:

- Environmental Disadvantages included ten variables: increase governance failure, increase transaction failure due to environmental liabilities, increase litigation and compliance breaches, increase fraud, increase scandals by perceived environmental irresponsibility, increase security and systems failures caused by environmental problems, increase marketing failure by perceived environmental irresponsibility, increase supply chain crises due to suppliers' environmental problems, increase insurance crises due to environmental disasters, and increase interest rates.

- 3Is included three variables: increase number of new regulations including environmental, increase competition for, and cost of, raw materials, and inflate cost.

This research might face expected or unexpected limitations while conducting research. For this study, the researchers used a quantitative research method and collected the research data through an online survey. One of the research limitations was that the researcher faced some difficulties finding sustainability studies done in Saudi Arabia. Also, many researchers are using online surveys as a data collection method, but it has number of limitations. These limitations are time, incomplete surveys, and the small size of the sample.

Some of the research participants were not familiar with the topic of sustainability, and they took a long time to read and answer the online survey questions. Also, some of the participants did not complete their survey which is time-consuming for the researcher. For instance, the researcher sent the online survey to 276 Saudi participants but only 110 surveys were completed. The researcher received large number of incomplete surveys from the participants because they answered the surveys on their smart phones. There are different sections and questions are not displayed clearly enough on smart phones and the participants failed to move their phone's screen. This research has a small sample size because it was limited to Saudi users who were using technology and studying or working in organizations.

This study provides several recommendations to the Saudi users which could increase their awareness regarding sustainable development and green information technology. The recommendations are: Firstly, looking at the current Saudi curricula, it is important to add the sustainable development and green information technology concepts to these curricula. Secondly, educate all students and increase the sustainability awareness in the education sector. In addition, all the Saudi organizations must put regulations, policies and goals to increase the level of the sustainable development. It is essential for Saudi businesses to adopt sustainable development and increase awareness by developing sustainability conferences, workshops, campaigns, and seminars. Businesses and organizations must provide their employees with sustainability training programs and encourage them to be more sustainable. Moreover, it is a great idea to reward employees who make sustainable changes. Finally, creating a sustainable development organization can help the whole community -especially the students—to increase their sustainable activities.

Finally, the concepts of sustainable development and green information technology are very important. Some of the survey participants were not familiar with these concepts. So, it would be beneficial to provide a detailed description to these users about sustainability before they completed their online survey. In addition, it would be beneficial to increase the sample size in the future for more accurate results. Furthermore, another continuing study might use qualitative methodology in order to investigate and get detailed information about sustainable development attitudes. Indeed, examining this research finding—as a secondary data analysis—will help to get great outcomes in the future researches.

11 Conclusion

This chapter provides a summary of the research significance, and the research question and objective. Moreover, this paper presents the research methodology, research design, and the survey results analysis. The researcher faced some limitations in the sampling, and incomplete surveys. Also, there were two factors for this research, factors of opportunities and risks. In brief, there were three opportunities factors which were: *new opportunities*, *resources*, *and green environment*, and risks' factors, which were: *environmental risks, and 3is*. Following these factors, there were activities that can help the Saudi users to become greener and more sustainable.

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Sustainable Transport—From Concept to Practice

Laurentiu David and Frantz Daniel Fistung

Abstract This chapter presents the sustainable transport concept and its particularities while introducing the main afferent terms and concerns about the transport sector, in general. The chapter starts by discussing the necessity for sustainability of this industry sector within the existing context of increased competition and concerns about reducing the cost of externalities. The chapter continues by presenting the past achievements to date, specifically the different models of sustainable transport analysis, support and implementation. In this vein, the chapter includes representative examples from around the world. Before concluding, the chapter suggests possible alternatives that might positively impact on the future of sustainable transport, perspectives, requirements, models and politico-economic support solutions.

Keywords Sustainable transport · Transport policies · Traffic · Congestion · Energy consumption · Externalities · Environment protection · Climate change

1 Introduction

The sector of transport, at the beginning of the third millennium, reveals an unfavorable evolution environmentally-wise. The continuous increase use of motor vehicles can cause major shortcomings in the global capacity to provide some resources for consumption such as oil. At the same time, both the emissions specific to the engines of vehicles, and the spatial occupation together with the increasingly accentuated artificial fragmentation of the ecosystems, can bring major damages to the natural environment and, implicitly, to the human existence.

From these perspectives, the new transport development policies (activities and infrastructures) should be built on the basis of current trends and should take into

L. David (✉)
Centennial College of Applied Arts and Technology, Toronto, Canada
e-mail: ldavid@centennialcollege.ca

F. D. Fistung
Centre for Industry and Services Economics, "Costin C. Kiritescu" National Institute for Economic Research, Romanian Academy, Bucharest, Romania
e-mail: dfistung@yahoo.com

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consideration the requirements of sustainable development. On one hand, the development of policies based on past statistical developments will possibly lead to the adoption of solutions and measures necessary to support or modify these developments in the future. On the other hand, policies should be developed on the basis of clear, imposed objectives, following the definition of plans for achieving them. In other words, for the first type of policies, every effort should be made to avoid obtaining unwanted situations, while in the second case, those necessary measures should be adopted to achieve the proposed objectives. The elaboration, in particular, of transport development policies often uses the two methods, unfortunately with a greater emphasis placed on the present situation, to the detriment of future goals.

From this perspective, the specific policies are presenting the unconditional development of transport as the basis for supporting global development and increasing of the general welfare of the mankind. These accumulations are only short-term, unfortunately, since most of the actions taken in transport use discretionary non-renewable or hard renewable resources producing serious, long-term effects on the environment and human health.

Thus, the inevitable need for a new approach to transport policies in order to achieve a balance between transport and the environment is unescapable. Such an approach can be that of sustainable transport, a concept based on the idea of sustainable development of our society.

In order to accelerate and improve the action aimed at developing a sustainable transport system, worldwide, it is necessary to understand not only the requirements of such an endeavour, but, also, what has been done so far and what the future prospects are. Without understanding what the concept of sustainable transport entails, its requirements and the achievements to date no steps can be taken in the right direction. In this vein, the present chapter intends to provide a brief introduction about the transport sustainable development concept, the support policies and the steps that need to be taken to implement it. The chapter intends, in fact, to underline the major role played by sustainable transport systems, within the context of sustainable development around the globe and to launch a new call to intensify the activities necessary to implement this kind of system worldwide.

The chapter is structured around three major sections (apart from the introduction and conclusions) which present, in essence, the defining notions of sustainable transport concept (definition, background, support-tools, main features, etc.), support policies needed and the measures that have been put into practice, as well as the perspectives and measures needed to intensify the development of it. Overall, the chapter will provide a concrete image of what the concept of sustainable transport is about, what was achieved to date in the field while understanding the obvious necessity of the proposed approach.

2 What Is Sustainable Transportation

2.1 Concept, Definition and Particularities

The concept of sustainable transport came to life within the context of increased concerns of our society about sustainable development. Thus, for over four decades, since the Stockholm Conference on Environment (1972), humanity has begun to recognize that the environmental issues are inseparable from those of welfare and economic processes in general. In this regard, the World Commission on Environment and Development organized by the UN had the task of defining a new concept of general development of human society, for the last decades of the second millennium and beyond. Only until 1987, the Commission identified over 60 definitions of the new concept (Fistung et al. 2005). However, after debates, not infrequently with partial controversial inflections, some versions of the Brundtland report, entitled "Our common future", which advocated a long-term strategic reconciliation between the economic and the environment, on a new path of development aimed at supporting the human progress around the globe were adopted.

In recent years, the issue of sustainable development, in particular, has been intensively studied and debated internationally. Exploring the European agenda, it can be observed that this topic was one of the central objectives of the EU development strategy since 1997, being directly addressed by the 2001, 2006 European Council onward. In the current view, sustainable development requires a simultaneous examination of the economic, social and ecological aspects, taking into account the natural limits. Within this context, transport is considered a fundamental element of human interaction, ensuring a unitary, but complex, character of our society economic and social life. It is eloquent that sustainable transport is mentioned in point 2 of the list of priority issues to be addressed in the EU's sustainable development strategy, as established in 2006:

1. Climate change and clean energy
2. Sustainable transport
3. Consumption and sustainable production
4. Conservation and management of natural resources
5. Public health
6. Social problems, demographics and migration
7. Global poverty and the issues of sustainable development

The concept of sustainable transport is a reaction to the harmful consequences of this activity, as well as to the economic performances achieved in the last half of the 20th Century. In fact, unsustainable transport can be characterized by excessive energy consumption, major pollution of the environment, important contributions to the deterioration of the population's health and often by unsatisfactory outcomes for the different economic and social groups it serves.

Sustainable transport or, as it is called, sustainable mobility, does not have a unanimously accepted definition. Since this sector was included, after 1988, as part of sustainable development, it is characterized in a broad sense by the ability to meet the demands of current mobility, without compromising the possibilities of future generations to meet their needs.

One of the most well-known definitions is the one given by the Organization for Economic Development and Cooperation (OECD), in 1994, respectively "Transport does not endanger the public health or ecosystems and satisfies the mobility requirements when: (a) the rate of consumption of renewable resources is below the rate of regeneration of those resources (b) the rate of consumption of non-renewable resources is below the development rates of renewable substitutes".

A more complex and widely accepted definition of the New Zealand Minister for the Environment ascertains that:

"Sustainable transport is about finding ways to reduce its impact on the environment, economy and society. These modalities include (WBCSD 2001):

- Improving the transport activity by increasing the quality of public transport, introducing and developing bicycle or pedestrian facilities, etc.
- Use of clean technologies and fuels.
- Use of telecommunications to reduce and replace physical trips such as tele-shopping or tele-activity, etc.
- Carrying out projects for cities with more intense pedestrian traffic and ecological transport".

In our opinion, sustainable transport represents "that complex system designed to meet the mobility needs of current generations, without damaging the environmental factors and health, and which must make the energy consumption more efficient, so as to make it possible to meet the mobility needs of future generations" (Fistung 1999).

Another definition that appeared in the research literature purports that "Sustainable transport is a complex system designed to ensure the mobility needs for the present generations, without damaging the environmental and health factors. By making energy and material consumption more efficient, it must make it possible to meet, in optimal conditions, from an economic-ecological-social perspective, the need for mobility of future generations" (Basgan 2001).

Recently, there is a tendency to use more frequently the term "sustainable mobility", in the context in which sustainable mobility extends the scope of the original concept, taking into account the social dimension of the activity, while sustainable transport is more focused on operational aspects of sustainability. According to this approach, the World Business Council for Sustainable Development defines sustainable mobility as "the ability to meet the needs of society to move freely, to have more free access and to communicate, relate faster, without sacrificing the present and future human or ecological values" (WBCSD 2001).

This statement covers a wide range of issues related to sustainable mobility:

- accessibility
- financial resources to be spent by users
- time required for the trip

- safety
- security
- emissions of greenhouse gases
- the impact on the environment and human well-being
- use of resources
- equity implications
- impact on public revenue and expenditure
- expected recovery rate for private equity.

Another shorter definition, highlights the consensus of the opinions of the various specialists in the field, including the representatives of some nongovernmental organizations, as follows: "Sustainable transport refers to systems, policies and technologies. It aims at efficient transit of goods and services. The concept of a city with as few vehicles as possible, with an increased use of bicycles, is getting more and more ground, together with activities in its early stages, such as telemarketing and teleconferencing. The terms "accessibility" and "mobility" are taking over that of "transport" (WBCSD 2004).

Of course, there is a considerable number of definitions of sustainable transport. Analyzing this multitude of definitions, three main categories can be distinguished.

The first category is that of definitions that accentuate the economic aspect. Thus, Shipper proposed the following formulation: "sustainable transport that one that involves the payment of the entire range of social costs by the beneficiaries, including those that are for future generations" (Schipper 1996).

The second category highlights environmental concerns. Thus, the OECD has proposed two definitions for the Environmental Sustainable Transport project (OECD 2000). The shortest definition is the following:

"An environmentally sustainable system is one that does not endanger public health or ecosystems and meets access requirements, respecting the two essential conditions (a) use of renewable resources are under their regeneration rates and (b) use of resources non-renewable are under the rates of development of renewable substitution products".

The longer definition purports that an environmentally sustainable transport system has the following characteristics:

- Allows the achievement of generally accepted objectives regarding the health and quality of the environment, for example those related to air pollution and noise, according to the proposals of the World Health Organization.
- Respects the integrity of the ecosystems, for example, does not cause excessive growth to the critical level, the degree of acidification, soil trophies and does not affect the ozone layer.
- Does not cause the worsening of global adverse phenomena such as climate change and the reduction of stratospheric ozone layer.

From the mentioned examples, it is highlighted that the first category of definitions focuses on the sustainable use of resources, and the second category brings to the fore the avoidance of the negative impact on the environment and health.

It is thus argued that none of these definitions captures the essential characteristic feature of sustainability and casts intergenerational equity, according to the concept of sustainable development launched by the Brundtland commission, which defined sustainable development as "development that meets the present requirements, without compromising the possibility for future generations to meet their own needs".

This type of definition is referred to by the experts as the most comprehensive definition, and this definition was adopted by the Center for Sustainable Transportation, having an official status at EU level. Such a definition underlines that sustainable transport has the following characteristics:

- allows the access to the basic and development needs of individuals, companies and societies to be secure and with the preservation of human health and ecosystems and promotes equity within a generation as well as between successive generations;
- it is financially accessible, it functions correctly and efficiently, it offers different possibilities regarding the mode of transport, it is an important element of supporting a competitive economy as well as a balanced regional development;
- limits the emissions and wastes to the possibility of being absorbed by our planet; it uses renewable resources at or below their regeneration rates and uses non-renewable resources at or below the rates of substitution products, while minimizing the impact of land use and noise.

The definitions presented above suggest that the general objective of sustainable development is to find an optimum of the interaction of the four systems, respectively economic, human, environmental and ecological, within a dynamic and flexible operational context. The optimum level corresponds to that long-term development that can be supported by the four systems.

As a result, it turns out that there is a consensus in the transport sector, that its functioning is not sustainable, having some negative consequences from the social, economic and environmental impact. There is also a consensus on the fundamental principles of sustainable transport, the most frequently invoked being the internalization of externalities, the principle of "user pays", and the fair competition between the different modes of transport.

An integrative approach to the main principles of sustainable transport was presented at the OECD International Conference in Vancouver, Canada, on March 24–27, 1996. The main eight principles of sustainable transport were:

A. Access

The contact between different people, the access to different goods and services, are important for the social and economic well-being of human communities. Therefore, it can be ascertained that although it is not the only way, transport is the key element for access.

1. Accessibility: People have the right to develop specific connections, in a reasonable manner, with other people, places, goods and services.

The strategic directions in which action must be taken to make this principle viable are:

Demand management

- Reducing the need for travel, while at the same time protecting the social and economic needs of access by changing urban structures, by promoting new communication technologies, developing more efficient packing methods, etc.

Diversification of options

- Improve connections by diversifying transport options, giving people more opportunities to meet mobility needs.

B. People and communities

The transport systems which are representing a vital point of an advanced economy can, directly, contribute to the well-being of communities.

2. Equity: National authorities, as well as the transport companies, must make all the possible efforts to ensure social equity, interregional and intergenerational, in order to meet the essential transport needs of the population without discriminating against some social categories in favor of others.

3. Health and safety: Transport systems must be designed to ensure the protection of health (physical, mental and social, respectively human well-being) and human safety and to contribute to the increase of the quality of life in all communities.

4. Individual responsibility: Transport decision makers have a responsibility regarding the integrated planning approach.

The strategic directions deriving from this principle are:

Urban development and transport planning:

- Concentrating urban development, limiting extensions and offering possibilities for mixed, diversified land use, through urban structure and more rigorous land use policies. This can reduce demand (especially for car travelers) by minimizing the distance between the point of departure and destination, as well as reduce habitat destruction and loss of agricultural land.
- Prioritization by means of less polluting modes of transport, with little impact on the mobilization requirements and the excessive use of space.
- Pedestrian and bicycle lanes should be attractive and become a viable alternative to car transport.
- Continuous development and increase of capacity and protection of public urban public transport systems.
- Greater integration of modes of transport, for passengers and goods, for better efficiency in the use of less polluting transport.

- Protection of historical sites and an archaeological resources, reducing noise pollution and taking into account aesthetic value in the planning, design and use of the transport systems.

Decision making:

- Ensuring the necessary conditions for transport planning, development and delivery activities in both the public and private sectors. These transport decisions must be integrated with the decisions taken in the fields of health, environmental protection, energy and the use of urban land.
- The decision making process must be open and include all the factors involved. The public must also be informed of the possible impact and should be encouraged to participate in decision making so that the desires of each community (rural or urban, cyclists or motorists) are understood and taken into account.
- Anticipating the social and environmental impact of the decisions regarding transport sector, and taking specific actions so that no negative phenomena can be recorded, instead of acting after these events have occurred. This would lead to considerable financial savings, as transport decisions often involve costly and long-term infrastructure investments.
- Taking into consideration the social, economic and environmental effects of these decisions at both global and local level.

C. Quality of the environment

Human activities can exceed the finite capacity of the environment to absorb waste, physically modify or destroy habitats, and utilize resources faster than their rate of regeneration or replacement. Efforts must be made to develop transport systems that lead to minimizing/eliminating the adverse effects on the environment which allow for the assimilation and regeneration capacities of ecosystems and meet the habitat requirements of other species.

5. Environmental pollution prevention: Transport needs must be ensured without producing emissions that can threaten public health, global climate, biological diversity or the integrity of basic ecological processes.

6. Use of land and resources: Transport systems must make efficient use of the land and other natural resources, in the conditions of promoting vital habitats and ensuring other requirements for maintaining biodiversity.

In order to implement these principles of preserving the quality of environmental conditions in practice, it is necessary to act in the following strategic directions:

Environmental protection and reduction of waste quantities

- Minimizing the quantities of harmful substances discharged into surface and underground waters, due to all types of transport activities.
- Minimizing the quantities of waste resulted from each phase of the life cycle of transport vehicles and infrastructures. The way to pursue is three-fold and aimed at: reduction, recovery and recycling.

- The rates of use of renewable resources must not exceed their rates of regeneration, and the use of non-renewable resources must be minimized.
- Emergency management systems must be able to respond to any adverse events involved in the transport activity.

Land use

- Ensuring a limited urban area, in order to reduce the destruction of the habitat and avoid the loss of agricultural areas or those destined for recreation and green spaces.
- Minimizing the impact on the natural habitat on the flora and fauna, on the people affected by the design, construction and functioning of the transport systems, including the road infrastructure between different localities.

Use of resources

- Reducing the consumption and emissions of fossil fuels, by increasing the efficiency and applying efficient management methods, in order to reduce the transport demand.
- Promoting the use of alternative and renewable energy.

D. Economic viability

Sustainable transport systems need to be much more efficient than the traditional ones. If the transition to sustainable transport requires some adjustment costs, they must be equitably distributed, likewise for the current costs.

7. Accounting for all cost elements

The decision makers in the transport sector must develop, as soon as possible, methods and tools of internalizing all the cost elements pertaining to the total real cost of transport which includes the social, economic and environmental costs in order to ensure a fair and equitable payment of this service by the users.

According to this principle, the strategic directions of action are the following:

Accounting for all cost elements

- Identification and recognition of indirect (hidden) public subsidies impacting on all required decisions.
- Taking into account all the social, economic and environmental costs, including long-term costs, related to each mode of transport and incorporating them as accurately as possible in the market prices.
- Taking all necessary measures to force users to pay the price calculated by taking into account all the afferent costs while respecting the principle of fairness.

8. Technological research and development

- Promoting and developing innovative alternative technologies that increase the access to the latest developments in the field and help protect the environment. The idea of offering a wide range of transport options should be emphasized.

Job creation

- Considering the potential economic benefits and use of the labor resources offered by the restructuring of transport systems.

In order to highlight the dimensions of sustainable transport, it was necessary to develop statistical indicators that reflect this aspect. It was also important, within the European context, to highlight the main policy guidelines for sustainable transport which will be presented below.

2.2 Sustainable Transportation Analysis: Instruments, Indicators

The transport sector is structured and analyzed, at international level through the use of numerous indicators. Not all of these factors, however, have an obvious connection with the sustainable development of transport. Below, in Table 1, some of the indicators highlighted by international statistics that have a direct connection with sustainable transport are presented.

In the literature of speciality there are numerous other indicators related to the development of sustainable transport; they are grouped in different categories. Some of these indicators will by highlighted, as follows:

Traffic

The traffic levels are the main determinants of the pressure exerted by the transport on the environment. The volume of transport depends on the evolutions of the demand (largely determined by the economic activity and the prices of the transport) and of the transport supply (e.g. the development of the road infrastructure). The specific indicators are:

- *freight transport* expressed in ton-km. The data covers the following transport modes: rail, road and inland waterways. Pipelines are not included. Data on air traffic require further development.
- *transport volumes*, *road traffic intensities and changes* in time. The data regarding the volume is expressed in tkm, respectively in km-vehicle per year; they cover total traffic as well as car traffic, as follows:
  - Per unit of GDP (vehicle-km/GDP($)),
  - Per inhabitant (vehicle-km/inhabitants)
  - Per unit of the length of the road network.

Table 1 Relevant factors in the transport-environment relationship

Sectoral trends and models	Interactions with the environment	Economic and political aspects
A. Modal sharing and general traffic trends – Trends of passenger transport by mode – Freight trends by mode – Trends and densities of the road traffic (passengers, freight) – Airport traffic trends: number of movements	**E. Land use planning** – Change in the arrangement of the territory on transport infrastructures – Accessibility to basic services	**K. Environmental deterioration** – Environmental damage due to transport – The social cost of transport
B. Infrastructure – Capital expenditures: total and per mode of transport – Road network: length and density – Railway network: length and density	**F. Air pollution** – Emissions from transport – CO_2, NOx, VOC, CO etc. (part of the total, by mode of transport) and emission intensities (per person, per vehicle-km, per GDP) – Population exposed to air pollution by transport	**L. Environmental costs** – The total costs for pollution prevention and control – Research/development expenses for "eco-vehicles" – The same for clean fuels
C. Vehicles and mobile equipment – Car parks (passenger, freight) – Structure of the fleet of vehicles (by type of fuel, age classes, part of clean vehicles) – Private car ownership	**G. Water pollution** – Oil evacuated from maritime transport (through accidents and discharges during operations)	**M. Taxation and subsidies** – Direct subsidies – Total economic subsidies (direct and indirect subsidies) – Relative taxation of vehicles and vehicle consumption (including road tax)
D. Energy consumption – Final energy consumption per transport sector (part of the total, per person, by mode of transport) – Consumption of road fuels (total, per vehicle-km, by type: diesel, petrol, other)	**H. Noise** – The population exposed to noise caused by transport higher than 65 dB(A)	**N. Price structure** – Structure of the prices for fuels used in road transport (by type of fuel) – Trends in public transport prices
	I. Waste – Transport waste and related recovery rates – Hazardous waste imported or exported (in tonnes)	**O. Trade and environment** – The indicators to be developed (e.g. trends in international freight transport, the relative importance of national vs. cross-border transport)

(continued)

Table 1 (continued)

Sectoral trends and models	Interactions with the environment	Economic and political aspects
	J. Risk and safety – Victims of road traffic (number of people killed or injured, per vehicle-km) – Dangerous materials transported by mode of transport (ton-km)	

Source Fistung (2008)

These indicators should be analyzed together with other transport indicators (specific to the infrastructure, vehicle parks), with energy indicators related to transport (energy consumption, prices and taxes) and with indicators related to the social cost of transport.

They should also be supplemented with data on: the average occupancy of passenger vehicles, the average load of freight vehicles, the relative share of public transport in passenger traffic and the importance of: (i) air traffic for passenger and freight transport, (ii) combined freight transport and (iii) modes of transport without a combustion engine. Other useful data include access to recreation, education and other services.

Infrastructure

The volume of transport depends on the fluctuations in the demand and supply of transport. Recent studies showed a clear link between the development of transport infrastructures and the increase in traffic volumes, especially in the case of road transport (mobility being directly induced by the road infrastructure). The capacity of the transport infrastructure, the accessibility and the geographical distribution, play an important role in the modal separation of the transport. Developing an efficient combined transport network for commercial freight traffic, for example, requires adequate and compatible infrastructure facilities, as well as appropriate terminal capacities.

The transport infrastructures tend to exert pressure on the environment through space consumption and physical transformation of the environment. Territorial planning for transport is often perceived as a key problem, because it is both a factor that generates transport activity and a factor that contributes to the pressure on the environment (e.g., waterproofing, fragmentation of natural habitats). The territory used for the transport infrastructure (road, railways and related facilities, etc.), may conflict with other territorial developments, influencing the access and property values.

The indicators presented, below, focus on the rail and road infrastructure and pertain to:

- the length and the density of the road network (in km and in the km^2 area of the national territory). The density of the road network provides an approximate indication of the space consumed by the road infrastructure. The land used for ancillary purposes related to the transport activity, such as parking in the case of road transport, also plays an important role, but it is harder to quantify, many times, these spaces being used for dual purposes (transport and parking).
- the length and density of the highways (expressed in km and in the km^2 area of the national territory);
- Length and density of the railway network (expressed in km and km^2 in the national territory), as well as the share of electrified routes (%).

These indicators should be considered together with the transport activity, including those regarding the trends of maintenance and capital expenditures in the transport infrastructure.

They must be supplemented with data on the infrastructure for combined transport, regional and local spatial planning models, and accessibility to recreation, education and other services.

Vehicles

The number of vehicles is a major indicator of the potential environmental pressure exerted by the transport sector. The increased number of vehicles is associated with a big potential sources of increased air pollution, noise, fuel consumption. The use of vehicles, also, implies potential problems because of waste management aspect resulting from their use. The environmental impact of road vehicles depends on the number of influencing factors, including the type and size of the engine, the type and quality of the fuel used, the average fuel efficiency, the age of the vehicle, etc.

In general, the dimensions of the vehicle fleets are related to the level of socio-economic development and related consumption patterns.

In this context, the specific indicators reveal:

- the trends of vehicle fleet evolution and intensities expressed as number of vehicles per unit of GDP, per inhabitant and length of road network.
- the structure of the vehicle fleet by vehicle type (cars, freight vehicles) and by fuel type (diesel, petrol, LPG).
- information on the portion of “clean” vehicles (for example, those equipped with catalytic converters).

These indicators, however, need to be analyzed together with other specifics of transport (traffic, infrastructure, energy consumption and prices), as well as those regarding car taxes, air emissions due to transport, exposure of the population to noise and waste resulting from the breakdown of vehicles for disassembly (recycling, reuse).

Energy consumption

Worldwide, the transport sector consumes over 60% of the petroleum products which represents about 98% of the total energy consumption in transport. The energy consumption structure of the transport sector is directly related to the composition of the resulting pollutant emissions.

The changes in fuel quality, as well as the introduction of vehicles equipped with catalytic converters influenced the level and composition of the exhaust gases. In the case of road transport, diesel and gasoline, for example, generate different types of air pollutants. Diesel-fueled vehicles emit less carbon monoxide (CO) and nitrogen oxides (NOx) than vehicles powered by gasoline, but more organic compounds volatile (VOC) and particles that can have cancerous effects. In addition, the combustion of diesel fuel generates sulfur dioxide (SO_2) emissions, but not lead emissions.

The specific indicators reveal:

– the final energy consumption (FC) of the transport activity, expressed in MTE and the relative contribution of the transport to the total final energy consumption (TFC), as well as the related intensities per unit of GDP and per inhabitant.
– the structure of energy consumption by modes (road, rail, air), expressed as a percentage.
– the structure of consumption by type of fuel (gasoline, diesel, LPG).
– the intensity of road fuel consumption by volume of traffic and by vehicle.

These indicators should be considered together with those pertaining to the structure of fuel prices, energy prices and taxes, the structure of the car fleet and the environmental ones.

The air pollution

Transport contributes, essentially, to the air pollution at local, regional and global levels. The emissions from the transport sector represent a major percentage of the total emissions created in industrialized countries. Most emissions are directly related to the energy consumption and a number of other factors, including engine type and size, type and quality of fuel used, average fuel efficiency, and vehicle's age.

Carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), suspended particulate matter (PM) and volatile organic compounds (VOC) are the main pollutants emitted directly by combustion of fuel into the engine (primary pollutants). They, all, contribute to the formation of secondary pollutants (photochemical oxidants, ozone, smog, atmospheric acids, etc.). Other pollutants include for example lead and SOx.

Reducing CO_2, NOx, VOC and macroparticle emissions are four of the six main criteria for achieving "environmentally sustainable transport (EST)". The recommended quantitative criteria for CO_2, NOx, VOC are 20%, 10% and 10% respectively, below the levels of total emissions recorded in 1990. For macroparticles, the recommended reduction is 55–99%, depending on local and regional conditions. In this context, the specific indicators aim at:

- the total emissions of CO_2, CO, NOx, VOC, macroparticles and SOx emissions from transport (i.e. mobile sources), their relative contribution to the total recorded

emissions, as well as the intensities of emissions per capita and per unit of GDP. The data refer to estimates of emissions at national level.
- CO_2, CO, NOx, VOC, macroparticles and SOx emissions from road transport and related intensities per unit of traffic volume (i.e. per vehicle-km).

These indicators should be taken into consideration together with those regarding transport trends (traffic, vehicle fleet, energy consumption) and specific indicators reflecting the urban air quality. If data availability permits, they must be divided by type of transport meaning by passengers, by freight and by mode of transport.

Risk of accident

Irrespective of the mode of transport, accidents occur on a daily basis in the transport sector. However, the frequency and severity of their occurence depend on many factors specific to each mode of transport. Certain risks such as those generated by the transport of hazardous waste by road or rail or by the accidental evacuation of petroleum products by tanks raise major problems especially from the perspective of the size of the damage. Although the disastrous accidents in air, rail and naval transport occasionally lead to major damage, they represent only a small part of the total number of deaths and injuries recorded in transport events, with road transport being the undisputed leader in this regard.

Road accidents generate high additional social costs. These costs depend on the property damage, injuries and deaths; they include medical costs, "estimated value of life, from a purely statistical point of view" and other afferent costs. Analyzing the number of people killed or injured, a partial, but conclusive assessment of this cost can be determined. Since most of the victims are caused by road transport, the indicators presented below refer only to this mode of transport:

- number of victims (i.e. people killed or injured)
- number of victims per transport volume (per billion vehicles-km)
- the number of victims on the vehicle.

These indicators need to be taken into consideration together with those pertaining to the volume of transport, intensity of traffic, as well as road infrastructure. These indicators must be supplemented with indicators on hazardous materials transported by different modes of transport and data on transport accidents involving dangerous substances.

Tariff and taxation policies

The pollution, accidents and traffic congestion generate a series of negative social and environmental side effects and lead to the development of external costs that are not internalized in the final transport prices. Therefore, the internalization of external (social) costs, through the use of economic and regulatory instruments, is considered to be a key element of the policies that aim at the sustainable and sustainable development of transport.

Prices play an important role as an information tool and are important determinants of consumer behavior. Thus, rising fuel prices for other goods tend to reduce the fuel demand, stimulate energy savings, and can influence the type of fuel used in the energy consumption.

Governments exert a major influence on energy prices through taxation measures. With respect to these aspects, the specific indicators refer to:

- fuel prices and taxes, in particular the price per liter and the related levels of taxation (in percentage of the price) for diesel, unleaded petrol and unleaded petrol.

These indicators should be analyzed together with those regarding the energy consumption per mode of transport and the volumes and intensity of traffic. Within the international statistics, there are several bodies dealing with the collection, processing and dissemination of data on transport activity. For the European Union, the main body that carries out these activities is EUROSTAT.

3 Policies Supporting Sustainable Transportation

The utilization of sustainable transportation methods is defended throughout the world, aiming in a general way to reduce energy consumption and the emission of polluting gases. Sustainable transportation methods aim to reduce the social and environmental impacts during the execution of transportation activities.

3.1 Examples for Sustainable Transportation Measures and Technologies Used or Planed, Over the World

Some examples of sustainable transport from around the globe are going to be presented next.

– Electric Car Suite

From electric cars, we're already graduating to electric hotel suites! First unveiled in Toronto in 2016, the Autonomous Travel Suite is an innovative vehicle works with the concept of the electric self-driving buses (Flynn 2019). It's completely programmable and runs on electricity, so it's powered with green energy, including solar panels that store energy until it reaches a recharge station or E-hotel. With every amenity you'd find in a luxury hotel suite, including king-sized beds, working toilets, steam showers, and WiFi onboard, this is a clean energy alternative way to travel that everyone will love. With carbon emissions at an all-time high, we all need to be thinking about sustainable transportation going forward. Community efforts have produced innovations ranging from bicycle share programs to the Mexicable, a cable car system to help rural commuters connect to the city in a greener, safer way (Flynn 2019).

– The Hyperloop

It is a high-speed means of transport that uses train capsules that are transported by a vacuum tube set. The Hyperloop was originally conceived by entrepreneur Elon Musk who presented the concept in 2012. From that moment on, the concept for the Hyperloop has been continually improved and tested (Flynn 2019, op.cit.).

– Ride share

Lyft, Uber, and other car share apps are gaining in popularity. They're a great way to make money and are often a cheaper way to travel than by car. Since they work as a carpool service, they're often a lot better for the environment. As smart cars and smart roads become more popular, your ride shares will be able to recharge on the go, and be kept aware of weather conditions, road work ahead, and traffic problems. It'll be easier, safer, and even more convenient to let someone else take the wheel.

– Cycling

Many cities have started embracing the health benefits of cycling. It cuts down on traffic on the road, and is a great green alternative for your commute. It keeps the city safer and healthier. Some municipalities have begun experimenting with rent-a-bike programs. In some cases, you put a quarter in, rent the bike to travel around the city with, and leave it at a designated location. In other cases, the bikes require a transit card. In cities where the emphasis is on sustainability, the population enjoys a high quality of life, lots of public parks and amenities, including, of course, bike paths! How do you improve on biking as the perfect solution to help carbon emissions and overall health? Take to the skies! The dream of elevated, interconnected bike paths that rise above the traffic to offer wide, safe paths for cyclists is still a dream in many cases. Creating cycle paths that snake an entire city is currently economically unsound, according to experiments in London. But smaller cycle paths in Denmark and China, which stretch, at their longest, just five miles, have so far been successful. Before long, the infrastructure is sure to catch up with our technology and ambition (Flynn 2019, op.cit.).

– Cable cars

From elevated bike paths to elevated cars? This isn't a futuristic dream. The Mexicable is Mexico City's solution to traffic congestion in urban centers and offers affordable public transit to poor rural areas. The seven-stop cable car transit system is designed to prevent the worst of the smog caused by traffic during the day. But it has also boosted sustainability in the city and encouraged the building of infrastructure which includes the rural communities, who now find it easier and safer to get to work every day. The cable is an innovative idea that works to support the health of both the individual and the community. And who wouldn't want to get to work by cable car?

– Combined transportation (CT)

The volume of international CT operations on trans-European corridors amounted to almost 4.6 million TEU in 2011 (EC 2015). The total traffic results from more than 100 individual trade lanes. The largest corridor by all measures is Netherlands–Germany. It is also the only corridor accounting for more than one million TEU and 10 million gross tones. The top 30 corridors account for about 92% of the total volume by TEU and tonnage. Container hinterland transport services feature strongly within the five largest corridors linking the Netherlands with Germany and Belgium, Belgium with Germany, and Germany with the Czech Republic and Austria. These results also reflect the importance of the largest EU sea ports of Rotterdam, Hamburg, Antwerp and Bremen/Bremerhaven.

3.2 Major Policy Actions Adopted in Order to Achieve Sustainable Transportation

In the United States, the transportation community has shown an increasing interest in sustainable transportation and its relationships to the land use and urban development patterns, economic growth, environmental impacts, and social equity. Many U.S. transportation agencies are re-examining their policies, planning approaches, and evaluation methods and are considering changes to every aspect of practice, from the materials and designs used in construction to the kinds of alternatives considered for implementation (US-DT 2001). Federal, State and local agencies as well as private organizations are working to translate the broad goals of sustainability into specific transportation policies, objectives, and programs.

The European policy on sustainable transport is an acute issue on the European Parliament's agenda, being at the same level with the energy and environment policies. The European policy is enriched with the recommendations of the Committee on the Environment, Public Health, Food Safety and those of the Committee on Industry, Research and Energy.

The approach is complex and has been generated by a number of current aspects of social and economic life of which is worth mentioning

- About one third of the total energy consumption of the European Union countries is due to the transport sector with the exception of the maritime and pipeline sectors; the road transport is the largest energy consumer with a weight of 83%, of the entire sector.
- Transport is responsible for 70% of EU oil demand depending on 97% of fossil fuels, the rest being covered 2% with electricity and 1% with biofuels.
- The energy efficiency of the different modes of transport has improved significantly in recent years and this aspect has allowed for a significant reduction of the corresponding CO_2 emissions per km from this perspective;

- The emissions caused by the road transport have decreased based on technological innovations and the intense efforts made by the motor vehicle industry. This result has been achieved, in particular, by introducing catalysts, fine particulate filters and other technologies that have contributed to reducing NOx and pollutant emissions by 30–40% over the last 15 years;
- However, these improvements have been neutralized and outweighed by the effects of the constant increases in demand and, respectively, the volume of activities in the transport sector. As a result, across the branch, emissions have remained steadily rising. In 2005 alone, for example, transports contributed 24.1% to the total level of greenhouse gas emissions (CO_2, CH_4, N_2O) produced in the EU, and, according to the Commission's forecasts the energy demand from this sector which multiplies the level of harmful emissions will increase by at least 30% by 2030;
- Urban traffic generates 40% of CO_2 emissions and 70% of other types of pollutant emissions(from vehicles and the agglomeration of road traffic, mainly, concentrated in metropolitan areas), causes, at EU level, serious economic and health losses estimated at about 1% from annual GDP;
- 70% of the prioritized projects of trans-European transport, approved in 2004 were oriented towards rail and naval transport, ways that are known to be the least polluting;
- The European Parliament stresses the importance of the transport sector from the perspective of employment, for growth and innovation, and considers that guaranteed mobility, safe and accessible to all, as a fundamental requirement of our lifestyle.

Significant changes in the European transport policy have led, more and more often, to the specific trends associated with the development of sustainable transport. Thus, at the OECD Conference on Sustainable Transport in Vienna in October 2000, the necessary guidelines for the development of a sustainable transport system were established:

- developing of a long-term vision, a scenario that supports a sustainable transport system with positive effects for the environment and health which will be advantageous in terms of mobility and access;
- evaluating the evolution of transport, in the long term, while taking into account all aspects of influence, of economic, ecological and social nature;
- defining specific qualitative objectives based on the criteria and standards of environmental and health protection and, implicitly, respecting the principles of sustainable development;
- setting specific objectives derived from the qualitative objectives particular to the protection of the environment and health, as well as the deadlines for reaching them;
- identifying the strategies necessary to reach the level of sustainable development of transport and the measures necessary to ensure the changes of the transport activity together with the introduction of new technologies;

- assessing the socio-economic implications of the scenario and their inclusion in the evolution based on the principles of sustainable development;
- development of packages containing measures and tools to support the development of a sustainable transport system. Policies will be adopted with respect to the technological side, infrastructure investments, taxation, demand for transport and traffic management, public transport improvement, encouraging walking and cycling;
- development of an implementation plan that includes the stages of using the packages of measures and instruments designed to lead to a sustainable transport system while taking into account the characteristics and circumstances at local, regional and national level. In is important to establish a clear work breakdown plan that includes the time period and the responsibilities for the implementation at each stage.
- implementation of measures to monitor the creation of the opportunity and public presentation of the strategy for developing a sustainable transport system. Well-defined indicators of sustainable transport will be used to communicate the results obtained.
- obtaining international support and cooperation to support this scenario. The political parties and the civil society will be involved so that their support can be reached. Programs will be developed to prepare and increase the level of specific knowledge.

At the same time, additional recommendations have been developed for the candidate countries of the European Union, aiming at:

- the involvement of all the factors in the elaboration of the studies on the environmental impact of the activities in the field of transport and, at the same time, the inclusion of a "zero" alternative which should be the minimum one for achieving the proposed purpose;
- avoiding the concentration of efforts for the priority development of a single mode of transport;
- transport strategies must be developed both in an integrated way, for the entire transport system, but also structurally, with specific elements for each mode of transport separately. Specifications are made on how current policies tend to encourage the faster development of road construction to the detriment of railways or public transport which will lead to an increase in the demand for transport directed to the road and implicitly to the construction of new networks. road (vicious circle);
- avoiding disproportionate investments, at regional level. The investments in transport must be made taking into account the strategies of development and spatial planning;
- development of a sustainable transport system must be the result of a mix of policies that include transport demand management, technical standards and financial instruments;
- the inclusion in the national development plans only of the projects of real priority, which are evaluated on the basis of the added value they produce on the

local economy and not on the place that the route has in international economic exchanges (it is part of the European corridors, e.g.);

- adequate policies for monetary activity evaluation should be adopted for all modes of transport, including external costs due to pollution, accidents and infrastructure degradation. These policies should be the basis for developing fair competitive relations between modes, in the transport market;
- adopting policies and actions to conserve the nature and to prevent its deterioration due to the transport activities;
- immediate introduction of EU requirements regarding the technical standards regarding the pollution levels and their permanent monitoring.

The transport policy in the EU was developed based on the existing modal share (road 44%, air 41%, rail 8%, river 4%) which is considered alarming, especially because it hides the tendency to aggravate the situation by increasing with 50% of road transport in the period 1998–2010 in the absence of measures to divert freight flows to other modes of transport. In this context, as well as, in order to reduce the number of accidents (40,000 road accidents/year, in the last years) and environmental degradation (Kyoto-8% CO_2 in 2008–2012) the EU stimulated the development of intermodal transport and the diversion of freight flows from road transport to the river and rail transport.

A comparison of the total external and infrastructure costs and the total tax and charge revenues for the various transport modes in the EU28 shows that the highest costs are found for road transport (about € 780 billon), with accident costs (€ 279 billion) and infrastructure costs (€ 184 billion) as the main cost categories (EC 2019). As the total revenues of road transport taxes/charges sum up to € 350 billion, about 45% of the road transport external and infrastructure costs are covered. For rail transport, the total infrastructure and external costs in the EU28 are equal to € 98 billion. The main part of these costs (about 80%) are related to the construction, maintenance and operation of rail infrastructure. About 20% of the total external and infrastructure costs are covered by tax/charge revenues (€ 20 billion). Finally, the total external and infrastructure costs for IWT in the EU28 are about € 6 billion, mainly covering infrastructure costs (about 50%) and air pollution costs (about 33%). As there is only a limited number of relevant taxes/charges levied on IWT in the EU28 (in many countries only port charges are levied), the cost coverage ratio found for IWT is relatively low (about 6%).

A variety of specific strategies are being pursued to increase the sustainability of the transport system in each of the countries of EU. Many of these strategies emphasize better operations and management of existing facilities and better design and operations processes for new facilities. In fact, in each country, the overall approach to sustainable development and sustainable transportation is described as a number of activities as part of a large, strategic program. Some of these activities are listed below:

– The European Commission proposed in 2002 a model/framework for transport costs that would ensure, until 2005 that the prices of different modes of transport will reflect their total social costs (including external costs).

- the implementation in 2003 of the methodological framework ensuring, for intelligent transport, the interoperability of payment systems for road transport took place;
- the prioritization of public investments for public and rail transport, inland waterway transport, short sea shipping and intermodal terminals was achieved. In particular, the Commission proposed in 2001 a revision of the directives for the trans-European transport networks and promoted, through a medium range term review of the Structural Funds programs, a significant reduction of the financing granted to road transport.
- the improvement of transport systems was achieved by solving transport links where they were missing, developing an open transport market and cooperation at European Union level (liberalization of the rail transport market, air traffic system). Until 2004, the European Single Sky system was operationalized.
- the promotion of teleworking systems by accelerating investments in new generations of communications infrastructure and respective services was pursued.
- in 2001, the implementation of the European Spatial Planning Observatory Network (ESPON) started, in order to define a set of territorial indicators for analyzing the regional impact of European policies.

Currently, the EU countries are trying out measures that address the following aspects (US-DT 2001):

- Land use-transportation relationships
- Transit
- Bicycling and pedestrian improvements
- Highways and the automobile
- New technologies and operations.

Land Use-Transportation Relationships

The coordination of land use and transportation is a key element in the European efforts to improve sustainability. Local and regional land-use strategies are viewed as important ways to manage transportation demand and transportation impacts. In each country, policies governing the location of land uses are designed to reduce trip lengths and facilitate the use of transit, biking, and walking—an approach referred to by many of those we met as the "short trip" land development strategy. Specific land-use strategies include the revitalization of existing centers, infill and brownfields redevelopment, the placement of high-density development near transit, development in and contiguous to existing centers already served by transit, and planning for compact, mixed-use suburban development that is both walkable and sufficiently dense to support transit services.

Although recent suburban development is lower density and more oriented to the auto than is the development in the urban core and older suburbs, the new development is still typically laid out with a mix of uses at a density that makes walking and biking practical for many trips and that can be effectively served by transit. Big box retail does exist in suburban locations, however, and is the topic of considerable debate.

Policies discouraging single-use, stand-alone developments such as shopping malls have been adopted in a few instances.

Transit

Transit improvements are another key element of the European strategy for sustainability, although in each of the countries we visited transit mode share has been declining overall. The relative decline of transit reflects the fact that a growing percentage of the population has access to private automobiles, and ownership and use are increasing at rates faster than in the United States. As in the United States, subsidies for transit have been a topic of considerable debate, and subsidies have been reduced in recent years but are still provided as a matter of social and environmental policy. Specific strategies to improve transit service include the development of extensive systems of priority lanes for buses, high-quality architecture and landscaping at transit stations and stops, planning for door-to-door service (including walk and bike access planning as part of transit planning), improved intermodal transfers, and high-quality customer information services.

Bicycling and Pedestrian Improvements

The denser land-use patterns found in European cities and suburbs make short trips conducive to biking and walking a realistic option for many. Infrastructure investments that create safe, comfortable facilities for the use of these modes further support biking and walking. Even though winters can be harsh in these countries, bicycling is recognized as an important transport mode, particularly for short trips. Extensive systems of bikeways, bike parking, and facilities for bikes on transit have been established. Traffic controls, including signalization and signage, are designed to accommodate the slower speeds and accelerations of bicycles and to improve bike visibility and safety. In urban centers, high-quality pedestrian spaces are plentiful, and more are being created by widening sidewalks, calming traffic, creating vehicle-free or vehicle-restricted zones, and bulbing out sidewalks at intersections to facilitate pedestrian crossings. The pedestrian-filled streets enjoy a feeling of vitality and safety (borne out by street crime statistics far lower than in U.S. cities of comparable size). Suburban towns and rural villages also are improving the infrastructure for bikes and pedestrians, with traffic calming a common practice.

Highways and the Automobile

While considerable emphasis is given to alternative transport modes, highways, automobiles, and trucks are increasingly central to European transport, and most policy initiative efforts focus on their management rather than on efforts to halt their use. Fuel taxes several times those in the United States do provide impetus for members of the public to consider alternatives, but such taxes have not deterred high levels of auto ownership and growing auto use (although per capita auto trips and travel are still only about half that of the United States). Parking is often scarce or expensive. Heavy traffic is found in most urban centers, on trunk line roads, and in tourist areas. Auto-related air pollution affects not only urban areas, but also has damaged crops and forests. Beyond using tax policy to influence travel choices, government agencies also have been testing public information campaigns that attempt to get the public to reflect upon the impacts of auto use and to consider trip chaining and scheduling to reduce harmful effects.

At the same time, the value of the automobile for personal mobility is respected, as evidenced by car-sharing programs designed to provide households the convenience of occasional automobile use without necessitating ownership or costly rentals. The Europeans are pursuing highway safety as a major aim of their sustainable development programs. Tough enforcement against drinking and driving is already an established program in several of the countries visited. Both speed management and traffic calming are part of newer programs aimed at a goal of improved safety and, in particular, a greatly reduced number of highway deaths. In addition, managing truck operations and regulating vehicles with the objective of improving truck safety is a current topic of considerable discussion.

New designs for highways are considered important ways to make transportation more sustainable, and in a number of projects the Europeans are experimenting with designs that aim to improve urban livability while providing good service quality. Streets and highways are being built and rebuilt to reduce negative impacts, in some cases by undergrounding major facilities. Parking also is placed underground in many areas, and is priced according to the resulting (high) cost. Joint development of air rights and partnerships with developers and owners of nearby properties are being used to help finance these costly projects. Traffic calming is widely used on residential districts and on major streets in shopping districts; the installations are made of high-quality materials and are well designed and landscaped.

Efforts are also under way to help protect biodiversity through good planning, location, design, and maintenance practices. For example, both on new facilities and in reconstruction projects, designers are creating animal crossing corridors. Bridge construction and reconstruction pays attention to the aquatic ecosystem and provides for fish and amphibian movements. On a number of highway projects, shoulders and medians are being preserved as habitat by maintaining, or reestablishing, appropriate plant species and ecosystems. Other examples of project design aimed at supporting a healthy environment include using bioengineering techniques to create environmentally sound, aesthetic structures; selecting materials to reduce noise and other environmental impacts; and incorporating recycled materials into structures and pavements.

New Technologies and Operations

New technologies also are playing important roles in the quest for sustainable transportation. Alternative-fueled vehicles are being tested both for transit and for personal cars, to reduce pollution and carbon emissions. In addition, intelligent transportation systems (ITS) technologies are being promoted to help auto and truck drivers plan trips more effectively, avoid bottlenecks, and travel at speeds that reduce congestion and improve safety. Improvements in truck technology are being sought, and incentives for truck emissions reduction include both emissions pricing and restrictions on the use of "dirty" trucks in sensitive areas.

Road pricing is discussed as a way to properly reflect the social and environmental costs of auto use but, as in the United States, it is being approached with considerable caution, because public support for it is mixed at best. Indeed, high fuel taxes have been the subject of several trucker strikes and political debates in recent years. A rail network that is somewhat less conducive to freight movements than that of the United States makes the Europeans relatively dependent on trucking, although rail freight improvements are actively under consideration. Meanwhile, advanced logistics and operations improvements are being implemented systematically, aiming to seamlessly move goods from ports to markets, maximize the capacity of existing facilities, reduce congestion, improve safety, and cut down on the need for facility expansion.

4 Measures for Achieving Real Sustainable Transport

With lots of traffic raising the stress levels, rising gas and insurance prices, the impact of transportation on the environment is an extremely important concern. Carbon emissions from the manufacturing and driving of vehicles are one of the world's biggest producers of greenhouse gases that are harming the planet.

As people become more interconnected, with intercontinental flights, and suburbs that are becoming miniature cities of their own, the problem of congestion, both in the traffic and in the air we breathe, is only getting worse. In heavily populated areas, such as some parts of China and Mexico, the air has actually become dangerous to breathe at certain times of the day. As a result, it came to no surprise the fact that green initiatives have begun all over the world.

Most consumers are likely to think that responsibility of lowering the impact of transport on the environment lies with the EU (33% of the six-market total), whereas France looks to the travelling public (32%) and the UK to the National Government (30%)—(Curry and Hughes 2012).

With different opinions being embraced across Europe, it is likely that a collaborative effort will be the most effective way of lowering the transport impact on the environment. In this respect, solving the issue of urban mobility is a huge challenge that will only be successful if government collaboration, infrastructure development and industry come together globally.

In order to ensure the sustainability of the European transport, it is important to adopt and combine many strategic political options and the involvement of larger constituencies which should include among other representatives of transport sector, public administration and civic agencies. Such an approach will be more likely to receive the approval of majority of stakeholders. Of the many necessary measures, it is worth mentioning those that are directly or indirectly related to road transport:

(a) the use of technological advances (measures to improve energy efficiency, new standards/standards for engines and fuels, use of new technologies and alternative fuels);

(b) the implementation of new market instruments (taxes/tariffs based on the impact on the environment or the degree of traffic congestion, fiscal incentives, adoption of a system of "emission allowance trading (ETS)", taking into account the characteristics specific of the different modes of transport);
(c) optimizing the use of specific means of transport and infrastructures to stimulate businesses and citizens to change their harmful habits (excessive use of their own cars for daily trips, lower unjustified demand for mobility, etc.);

From this perspective, the EU Member States must focus their actions on the key areas of the system:

(a) crowded metropolitan and urban areas where the majority of movement take place, mainly by road;
(b) the main European intercity corridors where most of the trade is concentrated within the EU and internationally;
(c) environmentally sensitive areas (alpine region, protected areas, etc.);

It is equally important to use economic incentives to promote vehicles with low fuel consumption and low emissions, such as: exemptions or tax deductions (annual taxes, compulsory insurance, payment of road use, etc.); reforming the vehicle excise system according to their level of pollutant emissions and energy efficiency; introduction of incentives for the removal of the most polluting vehicles and for the purchase of new cars with low emission levels.

The Council and the Member States are expected to accelerate their investments in the infrastructure and intelligent transport systems, especially:

(a) the completion, as soon as possible, of the priority projects in the trans-European network sector, of prime importance for the logistics of freight transport and for a sustainable European transport policy;
(b) solving the problems raised by the agglomeration of urban areas and along the corridors that cross sensitive areas;
(c) improving intermodal transport;

It can be asserted that it is necessary to develop a general applicable, transparent and comprehensible model to evaluate the external costs of all modes of transport, intended to serve, in the future, as a basis for calculating the fees charged for the use of infrastructures.

The model must be in accordance with the Eurovignette Directive and should be accompanied by an analysis of the effects of internalizing the external costs for all modes of transport and by a strategy of progressive application of this model to all modes of transport considered modes of transport more environmentally friendly.

In what concerns the problem of urban agglomerations which is responsible for 40% of CO_2 emissions and 70% of other pollutant emissions from vehicles, an approach, in line with the subsidiarity principle, must be implemented in a more ambitious way by seeking to adopt a cooperative strategy and coordination at European level.

An effective urban mobility policy must take into account both the transport of people and freight and, therefore, must be based on a global approach, able to bring together the optimal solutions for each particular problem. Urban areas continue to offer an adequate economic potential for modal shift policies in favor of public transport, walking or cycling, as well as for a new approach to urban logistics. It is considered that, in this context, it is particularly important to focus on technological innovations (wider use of intelligent transport systems, ITSs), on the more judicious use of existing infrastructures, in particular through demand management measures (use of differentiated charging rates - congestion charge and road pricing), on innovative solutions to optimize the integration of the urban flow of goods and, finally, on new solutions to optimize the use of private vehicles, such as co-sharing or car sharing (car pooling), as well as the possibility of working from home.

Among the European concepts to be considered in developing a viable transport development strategy some of the most important are:

- sustainable development of the public and private transport system, a concept that includes both aspects related to resources, waste, pollution, etc. and the social dimension of transport development—population mobility.
- development of the competition:
  - competition on the market between modes of transport, between groups of operators or between individual operators.
  - competition for the market by offering competitive concessions for using individual routes or the entire network.
- integration of services at modal level, intermodal interface, integration with other public services and integration in the socio-economic environment.
- stimulating the dissemination of information and knowledge on transport services with the help of best practices and advanced technologies.
- establishing the quality criteria for the modes of transport.
- establishing an adequate political and legislative framework to promote the increased use of transport systems.
- efficient use of financial instruments in order to optimize the economic contribution of the transport system at local, regional, national and international level.
- social equity, considering that the transport is interdependent with the entire field of land use, of the socio-economic activity planning.
- environment protection.

The European Commission has proposed to the Council of Europe at the Gothenburg Conference a series of measures to improve the transport systems in accordance with the principles of sustainable development. It is worth noting that the transport and land use sectors are treated, for the first time in the European Union's political strategies, within the same group of priority issues. This translates into the fact that the focus on the development of European transport will be placed on the intermodal transport to the detriment of one "door-to-door". The supporting platform for this argument stems in the density of transport networks throughout Europe, the territorial limitation of their further development, as well as the high share of short-haul transport. This can lead, however, to other problems, raised by the increase in the volume of marginal services (firstly those of transhipment and storage, for the transport of goods) and by the increase of the transport times.

If for the land and river transport this option can be considered optimal or can be optimized, in the air and sea transport this aspect it is debatable from the point of view of economic efficiency. First of all, the impact that the development of intermodality will have on the constructions of air and sea vessels is quite relevant. Second of all, this option implies an increase of the production of small and medium capacity vessels for relatively short travel routes. Adversely, the maritime and air transport contain a global component that no longer limits the transport routes to the European space which would imply the promotion of the construction of large capacity ships capable of carrying out long voyages.

The document adopted in Gothenburg reveals the following goals and tasks, with an emphasis on developing the transport sector on a competitive and sustainable ground:

Main objectives

– decoupling the evolution of the transport from that of the GDP, in order to reduce the traffic congestion and other negative effects caused by transport.
– replacing the road transport with the rail and naval transport, as well as the individual transport with the public passenger transport so that the proportion of road transport will be not higher than that recorded in 1998.
– promoting a balanced development of the regions, by reducing disparities in economic activities and maintaining the viability of the urban and rural community, as recommended by the European Spatial Development Perspectives (ESDP).

Adopting sustainable development policies for the transport systems does not induce an immediate and total change of the lifestyle. The most important objective is that by which any displacement that produces negative effects on the environment and human health occurs simultaneously with the adoption of measures aimed at reducing these effects.

In order to develop a Sustainable Transport System (STS), it is necessary to consider some aspects, such as:

A. Socio-ecologically:

– increasing the accessibility to the STS by adopting the most viable variants which fully satisfy the mobility requirements of the society;
– ensuring the transparency of all the measures and their explanation while encouraging the public participation in debates on the usefulness, purpose and costs of these actions;
– the assessment of the social and ecological impact before the application of any action;
– providing permanent information and education in the spirit of STS promotion;
– giving priority to the development of transport systems, in favor of ecological ones, with minimal or no negative impact;

- reorientation and reorganization of all modes of transport in the direction of STS;
- minimizing the production and disposal of residues, for each phase of the life cycle of vehicles, at the same time with their recycling;
- stopping the degradation of habitats, the division of ecosystems and the loss of agricultural land or social destinations;
- reducing or eliminating sources of pollution (fuels, components of vehicles);
- covering all the transport needs for the members of the communities, at the same time with increasing the quality and safety of life.

B. Economic-ecological:

- internalization of external costs including those with long-term effect;
- promoting research and development programs that focus on the development of strategies, plans and measures necessary for the development of STS;
- establishing the specific indicators of the STS which will need to be constantly monitored, their value should be in accordance with the general indicators of socio-economic development of the society;
- ensuring a higher use rate for renewable resources compared to non-renewable ones, at the same time with the use of new types of materials and materials, technically and ecologically efficient;
- reducing the overall fuel consumption by streamlining systems and activity mainly by adopting both the minimum travel routes and an appropriate driving mode;
- adopting administrative and fiscal measures, in order to encourage green transport (a priority must be public transport) to the detriment of polluting ones;
- establishing special funds for the development of STS;
- the use of specific forecast models, necessary for the long-term adoption of all the actions that will contribute to the implementation of the STS by concomitantly considering the ecological, economic, social, financial and urban planning aspects.

Obviously, a fair policy regarding the development of a sustainable transport system must contain specific elements at both national and local level.

a. At national level, depending on the restrictions imposed by the level of economic development, measures of fiscal (taxes, charges), compensatory or informational nature can be adopted. These regulatory actions are aimed at creating the legislative basis for the future development of the process. Adopting a coherent and stimulating legislation is the key to success in this endeavor.

The measures in the field of fiscal policy are, also, of great importance. They must aim both at reducing the proliferation of negative effects due to the transport activity (for example chemical and noise pollution), and at compensating for the factors not directly involved in the activity. To a large extent these goals can be achieved by internalizing the external costs. In order to achieve to achieve this objective, in the case of road transport, the following model is suggested:

- an annual tax corresponding to the fixed costs of the infrastructure;
- transport charges related to variable costs, such as:

  - the road maintenance fee;
  - traffic and accident surveillance fee;
  - energy taxes and CO_2 emissions;
  - air pollution charges with pollutants and volatile organic compounds;

- noise pollution charge.

The annual fees must be differentiated according to the characteristics of each type of vehicle. The transport taxes must be included in the price of fuels. In addition, for heavy vehicles, an additional charge, generically called charge/kilometer should be introduced.

Because the internalization of the external costs will lead to an increase in the price of transport for polluting vehicles, the necessity and the purpose of such measures must be clearly explained to the public. At the same time, it is necessary to continuously adapt the process to the existing circumstances.

From the revenues obtained by collecting these taxes which can be estimated as quite high, the entire process of modernization of transports must be supported according to sustainable development principles, an important percentage being oriented towards the introduction of social measures for those affected by the negative phenomena produced by the transport activity.

In addition to these actions, national measures should also be taken into consideration:

- adoption of less polluting modes of transport. In this context it is worth mentioning the support of the intermodal freight transport.
- restoration of existing infrastructures, in order to ensure qualitative parameters of the transport activity encouraging the use of "clean" fuels, by imposing much lower prices compared to other types;
- improvement of emission monitoring systems, in order to adopt the proper measures aimed at maintaining the pollution levels within the allowed limits;
- adoption of measures to reduce the effects of noise pollution, vibration, etc.

b. At fiscal level, measures of a fiscal nature can be introduced to support the national ones, though the main actions to be taken would be administrative. Overall, these types of actions must:

- promote less or no polluting transport, such as public transport, walking or cycling;
- adopt regulations aimed at restricting the speed of movement on certain portions, on the access of cars in certain areas (historical, central, etc.), on the use of non-polluting fuels for vehicles subordinated to the public administration, etc.;
- adopt of fiscal measures at the local level when the national ones are insufficient. It should be mentioned that it is necessary to avoid imposing more taxes on the same type of effect (for example, in the case of internalization of the external costs specific to road accidents, it is not necessary to introduce simultaneously a fixed and variable annual tax, deductible from the price of fuels).

It is obvious that, overall, the total value of the external costs exceeds that of the taxes paid by the users, the difference being borne by the society.

In the case of rail and naval transport, the degree of recovery of the external costs is even lower than that of road costs due to the specific problems that may arise in the evaluation of the costs of using the infrastructures.

For all modes of transport, however, in order to increase the degree of recovery, the measures of internalizing these external costs must be adopted. As indicated above, this can be achieved either through a regulatory policy or using specific economic instruments. In the case of a global strategy, the balance between the adoption of one mode of transport or the other must be analyzed very carefully for each individual case (road transport, rail, etc.).

The economic instruments that can be used to internalize the external costs have the following common elements:

- acts through financial incentives;
- the polluter has the possibility to act voluntarily only at the market signals, corrected by this process or by setting prices for resources in common property (public goods);
- local or central authorities are actively involved, from an institutional, legal, economic, and administrative point of view;
- there is a will to maintain or improve the quality of the environment by applying economic instruments.

The essential purpose of an internalization policy is to increase the efficiency and fairness of the transport systems. Therefore, the prices are intended to reflect the true value of the costs, so that both individuals and businesses have the opportunity to make the most correct decisions regarding the way of moving, in time and space, to of goods and persons, on an efficient economic basis.

By introducing economic instruments, a number of advantages can be obtained, in the activity of preventing the deterioration of environmental and health factors, of which some are mentioned below:

– promoting, among the polluters, an appropriate behavior to protect the environment by reducing/eliminating the pollution level;
– maintaining permanent incentives to introduce new anti-pollution technologies as they become available on the market;
– creating conditions for the development of new and efficient technologies (less polluting).

In order to successfully implement the measures specific to a policy of internalizing external costs, certain principles must be respected, such as:

– the level of the imposed taxes must reflect, as accurately as possible; this will lead to a decrease in the value of externalities and to an increase in the benefits to society;

- in order to encourage users to take the most appropriate measures to reduce externalities, an efficient system must introduce taxes with differentiated levels, depending on certain specific characteristics (pollution level, vehicle type);
- the fee structure must be clear to the users;
- the tax system should not cause discrimination between the different modes of transport;
- the economic instruments used should include for all modes of transport in the price of the travelling as accurately as possible the level of the total social costs.

In order to adopt the most effective measures of economic policy for reducing externalities, the following selection criteria can be chosen:

- Effectiveness → compared to the possibility of reaching the proposed objectives;
- The principle of social costs → the cost representing the monetary compensation that any individual claims for obtaining the desired living environment, prior to its modification by adopting a certain measure;
- The cost/benefit ratio → will be taken into consideration the total social cost;
- The static and dynamic values of the cost/benefit ratio → the difference between the static and the dynamic value can be highlighted as follows: there are certain maximum permitted levels of pollution levels, for both road transport, for example and for power plants; the static ratio is defined as the equality between the reduction of costs by reducing with a unit the level of pollution due to both road transport and the activity of a power plant. The dynamic report aims to satisfy this condition not only at a certain time (generally, the analysis is done towards the end of the period of application of the measures), but also throughout the period in which the regulations are in force;
- Transparency → simplicity and permanent presentation of the measures taken;
- Fair distribution → should be avoided in situations where certain "weaker" segments (for example the population whose incomes are lower) are affected;
- Occurrence of side effects → the effects that a measure can create on other causes, leading to additional effects (positive or negative).

To improve and increase the accuracy of research, a set of new indicators are proposed to be taken into account for determining the degree of sustainable transport development. The environmental monitoring system must take into account the fact that during the monitoring of environmental indicators, at national or regional level, it is impossible to distinguish between the environmental impact produced by the transport activities and the impact produced by other activities/interventions (e.g. industrial activities).

In order to monitor the effects of transport on the environment, a set of environmental indicators is proposed for each of the relevant environmental objectives. Monitoring indicators should be used selectively when monitoring environmental effects, depending on the characteristics of the projects to be developed. It is assumed that those environmental objectives used in the evaluation and selection phase of the project will also be used for monitoring. By monitoring and summarizing the monitoring results of each project, it will be possible to estimate the overall effect of transport on the environment.

The proposed environmental indicators must be incorporated in the general system of monitoring the transport activity and infrastructure of any country. This monitoring should be carried out over the entire duration of the scheduled period (annual report or at least a semi-annual interim report from the beginning of the project and one at the end of the project, depending on the duration), and the results should be made public regularly, ideally in electronic format.

5 Final Thoughts

5.1 Conclusions

Our planet is becoming more and more populated. Obviously, the statistical figures are a live testimony of that. With the passing of time, human activities have diversified a lot, especially during and after the Industrial revolution, which has led to a sharp increase in transport demand. The relationships between populations, nations, regions, continents of the globe have intensified, over the years. and led to accelerated developments in the transport sector. Unfortunately, the negative effects of these developments are increasingly felt, meaning the increase of pollution of any kind, the intensification of the global warming phenomenon and the deterioration of the level of health around the world, by all the inhabitants of the planet.

Equally true is the fact that land transport is responsible for more than three quarters of the pollutants (including in this category the problem specific factors such as agglomerations, deterioration of infrastructures or accidents), which means that, at least until now, water and the sky were not considered as priority elements for the development of transport.

Therefore, it can be asserted that the main reason behind the elaboration of environmental policies, in the last decades or so, was that under the mantra of the sustainable development concept, the idea of sustainable transport was placed at the forefront Within this approach, the main idea was to discourage the development of road transport, the least friendly to the environment.

As it was mentioned in the chapter, the definition of the sustainable transport concept has been, intensely, debated. Irrespective of that what is unanimously accepted as a proper definition, the most important aspect is the need to, urgently, apply measures to reduce the effects caused by the existing transport systems. Within this context, there are two major opinions, each arguing that the actions for the development of a sustainable transport system must focus, primarily, either on the sustainable use of resources, or on the drastic reduction of the negative impact on the environment and health. Though both views are well-intentioned and accepted by both scholars and practitioners alike, the collaboration between them, as well as the adoption of a common plan would certainly lead to the development of a successful policy.

In accordance with the actions aimed at promoting a sustainable transport system, specific indicators have been adopted and adapted in some cases. They are representative for all four sectors that are intertwined, within the concept of sustainable development: ecological, economic, social and technical. Based on these indicators, numerous support policies have been created for the implementation of a sustainable transport system.

Unfortunately, as it becomes evident from the examples presented in the chapter, the measures taken up to now were not concerted and complementary and, as a result, in different regions of the planet self-sustained actions were carried out without a relevant impact, at a global level. For this reason, but not only, it is necessary to approach the activities supporting the development of a sustainable transport system, at a global level.

However, this can only be achieved by adopting a common agreement, recognized by all states. Perhaps a strategy for supporting a sustainable transport system, adopted under the aegis of the UN, would be one of the best solutions.

5.2 Findings and Limitations

Even though the concept of sustainable development has been the focus of environmental research in the past four decades, the sustainable transport concept is rather new. However, the need to remedy the serious distortions and negative effects of transport on the environment and human health has forced humanity to take the problem of sustainable development of transport, in time, more and more seriously. Though the initial achievements were timid, at the beginning, new elements were added to them permanently, so that, from now on, we can see an implication, worldwide for the rapid and efficient implementation of the sustainable transport systems.

The intensification of the negative effects produced by transport activities and infrastructures (chemical and noise pollution, occupancy of land that can be used for other purposes, accidents, lowering of health level, congestion of transport networks, increasing energy consumption) made not only necessary, but also mandatory, the implementation of numerous methods and techniques to support the development of sustainable transport.

Given the speed of implementation of these methods, as well as that of introducing into practice new technologies, products, more environmentally friendly, it is presumed that in the near future the sustainable transport will become the major element in the transport economic sector.

The present analysis has highlighted the fact that things are moving slowly but, fortunately, in the right direction. Notwithstanding this, the speed of implementation of a sustainable transport system is low because of the lack of a unanimously global agreement in this regard. Moreover, the specific elements and components of such a policy are not clear. There are areas in which numerous measures/methods are proposed, but the lack of action with respect to their implementation impedes the achievement of spectacular results. As an example, we recall the numerous attempts to develop a model, unanimously accepted, for evaluating the external costs caused by transport activities and subsequently for internalizing them.

Less attention has been paid, also, to the possibility of encouraging a decrease in transport demand which would lead to remarkable results at the system level (transport-environment pollution-mobility). A successful sustainable transport strategy requires, as a supporting platform, that all stakeholders in the transport market (transport manufacturers, infrastructure builders, fuel producers, carriers themselves) be interested and pursue activities conducive of such effort. Unfortunately, some of the stakeholders have interests that are contrary to the creation of sustainable development policy and seek to delay the implementation of support policies for sustainable transport as much as possible. A conclusive example is that of electric vehicles. Even though the electric cars were conceived and prototyped many decades ago, their design and production, on a large scale, was delayed/obstructed by the major fuel companies which had a major interest in selling their manufactured petroleum products, in particular, for motor vehicles.

5.3 Future Research

Unfortunately, the degree of achieving high levels of sustainable transport depends on the actions undertaken not only at the global level, but also at the zonal, regional and local level. This is an issue that needs to be reviewed. The future of transport, will be glorious one if the people of today will place before themselves the needs of their grandchildren. And, supposedly, everything will have a favorable turn out.

Further research will also analyse aspects that were not the subject of this analysis. More specifically, the models for evaluating the external costs caused by transport and the concrete measures adopted for their internalization. At the same time, the financial commensuration of the adoption of such measures will be considered, together with the highlighting of the measures and an implementation schedule for reducing transport demand, without reducing the mobility needs. Also, the authors will initiate discussions, at expert level, internationally, for the adoption of a Sustainable Transport Strategy which should be adopted within the UN, as a natural continuation of the concept of Sustainable Development, now launched for more than four decades (Brundtland Report).

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The Advantages and Disadvantages of Sustainability Awareness in Indian Society

Rajbir Kaur

Abstract India is one of the top countries which are in danger of suffering the worst effects of climate change. As the planet warms, agriculture and farming income will suffer from rising temperatures and less rain. This research was conducted to reveal the risks and advantages associated with sustainability in India. The literature has been reviewed to obtain relevant information and knowledge. The meaning of 'Sustainability and 'sustainable development' has been discussed in the paper. All the initiatives undertaken by organisations, either public or private, and by the government in the education sector, and at individual level have been elaborated in this study. A qualitative approach was adopted to gather data via an online survey. A total of 111 responses were analysed to obtain appropriate and accurate results. The findings show that people have a general understanding of how to protect the environment. But in terms of technology and electronic devices, they are not very concerned about the harmful effects of using the devices in excess. They seem to have little idea about reducing, recycling and reusing electronics and IT devices. For some people, sustainability was a new term. Later, the findings were analysed to generate the new advantages and risks associated with sustainability. In the final chapter, the limitations, recommendations for sustainability initiatives, and suggestions for future research are presented.

Keywords Sustainability · Sustainable development · Awareness · Corporate Social Responsibility · Triple Bottom Line

1 Introduction

This research has been conducted to determine the level of awareness of Indian society regarding the issue of sustainability. It focused on the risks and advantages associated with sustainability. This research targeted people who are using and changing their electronic devices without concern for the negative effects of

R. Kaur (✉)
School of Management, Curtin University, Perth, WA, Australia
e-mail: Rajbir.Kaur1@Graduate.Curtin.edu.au

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technology on society and the planet. At present, all nations are aware of the degradation of earth due to industrial development and the excessive use of technology. The developed countries are taking initiatives to further their development sustainable ways. These countries are also supporting the poor and developing countries to develop in a good way without destroying their natural resources; developed countries are giving financial support and helping less fortunate nations to improve their people's quality of life. The Sustainable Development Goals (SDGs) of the UN have been agreed to by 193 countries as a means of securing a sustainable future. India is one of the countries that are taking significant steps to become sustainable.

India is a developing country. It has a pool of human and natural resources. It is the second most populous country in the world. With its rapidly growing population, India is facing a shortage of resources. Compared to other nations, India faces more challenges like water scarcity, pollution, low energy supplies, exploitation of human rights, issues of sanitation and many more. These challenges are not only limited to the degradation of nature or deforestation, but also has other issues like corruption, and political and economic issues. The environmental issues are predominantly affecting large Indian cities such as Delhi and Mumbai. These cities are experiencing high levels of every type of pollution. The worst air pollution was noted on Nov 18, 2017 (Irfan, 2017), when the whole of Delhi was covered by a blanket of smog. The situation is worse for people who live in slums. The villages of India are faring much better than the cities in terms of environmental issues, but they lack adequate facilities.

Due to all these reasons, it is very important to achieve the 17 Sustainable Development Goals (SDGs) developed by the UN. India is working towards attaining these goals to reduce poverty, reduce hunger, increase public access to clean water, sanitation, urbanisation, and gender equality, in order to enhance the quality of life. India has taken various steps forward to save resources and energy, reduce gas emissions and save the forests. As India is developing, it is difficult to manage all these issues while development is taking place but, nevertheless, India is progressing well. Sustainability needs a balance between 3Ps (People, Planet and Profit) and each individual needs to work to achieve a balance in terms of 3Ps (society, environment and economy).

The trend of industrialization and modernisation is pushing the earth to dangerous levels. The industries are using non-renewable energy beyond their limits. They do not have appropriate and effective measures for using the resources responsibly and controlling the industrial wastage. Due to the industrial revolution, people are moving to the urban areas and cities are getting more congested and overpopulated. This is causing of unemployment, degradation of life quality, poor health, water and food problems and an increase of slum areas. Poverty is also one of the major issues the world is facing today. Many people do not have access to clean water, necessary food, health facilities, sanitation, homes, less social security and lots of other hazardous conditions.

This research seeks to determine whether and to what extent people in India are aware of environmental issues. This study focuses on one specific area of sustainability: the use of technology, because technology is the main concern of current circumstances. People use electronic devices in each field of life, be it either personal or professional. They use social networking to connect with people, share information, or conduct business. They spend much time and energy on using these devices. The harmful signals produced by the internet affect the biodiversity of the planet. So, it is vital that we know the adverse effects of using technology, so that effective measures can be taken to reduce the impact on the environment.

This study covers definition of Sustainability, history, CSR, TBL, Advantages and Disadvantages of Sustainability, Sustainability Awareness in Indian Education and Businesses. The research methods and questions used to conduct the survey are also explained in the chapter. Furthermore, the limitations of this research were presented followed by future research recommendations.

2 Background

2.1 What Is Sustainability

Sustainability is the ability to maintain the available resources in terms of society, the environment and the economy for the use of present and future generations. Today, everyone wants a luxury lifestyle that needs a lot of water and energy. While maintaining the lifestyle and increasing the use of these resources, we create excess contamination and surplus waste. This waste should be managed so that it will not harm the environment. Various definitions of sustainability emerged when the world started to think about this concept. Some people saw sustainability as the second form of environmentalism while others saw it as having both ecological and social justice components.

Sustainability Dean **Christopher Boone** defined sustainability as, "It's looking after the Earth as a system, people as a system, and trying to find ways we can both survive and thrive in the future" (Seckel, 2015, p. 1**)**. According to the University of Alberta (UA, 2015, p. 3), "Sustainability is the process of living within the limits of available physical, natural and social resources in ways that allow the living systems in which humans are embedded to thrive in perpetuity".

The school of sustainability has an official definition for sustainability as "Improving ecological integrity, human well-being, and social justice for present and future generations is the grand challenge of sustainability" (Sackel, 2015, p. 1). This definition of sustainable development given by the Bruntdland report gained widespread acceptance and it is still used today.

Moreover, sustainability is the act of balancing the line between the needs of technical and economic development and the need for safeguarding the environment. It relates to renewable resources, recycling the wastage, reducing the CO_2 emissions, and saving and protecting the environment. It is concerned with human development, social facilities, equity, education, diversity, opportunities, energy conservation, fiscal stewardship, resource development, waste reduction, economic growth, and research and development without compromising the quality of life.

2.2 History of Sustainability

Peter Bruce provided a brief history of sustainability by dividing it into two eras. According to (Bruce, 2017), the first era was from the dawn of industrialisation to the early 1960s and the second era is from the 1960s to the present.

First Era: Sustainability was the concept of forestry with the meaning of not to harvest more than the forests yield. The German word '***Nachhaltigkeit***' (sustainability) was used for the first time in 1713 (Heinberg, 2010). A German forester and scientist, Hans Carl von Carlowitz used the word 'sustainability' for the very first time in his book 'Sylvicultura Oeconomica' in 1713. After that, French and English foresters started the practice of planting trees for 'sustained–yield forestry' (Kuhlman & John Farington, 2010).

The industrial revolution began in the mid-1700s in Great Britain when machines started replacing manual work, and fossil fuel began to be used instead of wind, water and wood. In the early years of industrialisation, people started to raise their voices. In 1808, William Blake in his poem "Jerusalem" commented on England's cotton mills calling them "Dark Satanic Mills". Charlie Chaplin also satirized the assembly line in his movie 'Modern Times' (Bruce, 2017).

Second Era: In the second era, beginning in the 1960s, people became concerned about their rights, their environment, justice and warfare. Many ground-breaking steps were taken in this era to make the world sustainable. The impact of the Industrial Revolution on the environment was not registered until 1960. In 1960, Rachel Carson made the public aware of the adverse effects and causes of human outgrowth resulting from the Industrial Revolution. She wrote a book 'Silent Spring', criticising a powerful and robust chemical industry and raising questions about the human's impact on nature (McLamb, 2011). In 1972, the term 'sustainable' was used for the first time 'in the modern sense' by the Club of Rome. From a model to people.ome needs to delete, all words in Italic This was used in the Club's publication '*Limit to Growth*' that described a state in which the global population would achieve balance or equilibrium. The authors were looking for "*a model output that represents a world system that is: 1. sustainable without sudden and uncontrolled collapse; and 2. capable of satisfying the basic material requirements of its entire people.*" (Stofleth, 2017, p. 1). The report of the Club of Rome succeeded in influencing global public policy. This report predicted that many resources that are mandatory for human life would vanish within the next two or three generations (Kuhlman & John Farington, 2010). In 1983, The Brundtland Commission was formed to continue the work sustainabilitySustainability development. In 1987, the Brundtland Report, "Our Common Future", was presented by the United Nations World Commission on Environment and Development. According to the report, 'Sustainability development' (Pisani, 2006, p. 83) is "*development that meets the needs of the present* *generation without compromising the ability of future generations to meet their own needs*". (Table 1).

2.3 Triple Bottom Line

The Triple Bottom Line concept was coined in 1994 by John Elkington, a business consultant who described the economic, social and environmental value that may increase outside the firm's financial bottom line (Hammer & Pivo, 2016). It is focused on evaluating the assets more accurately in order to employ the capital as effectively and efficiently as possible. It differs from other traditional measures of profit, ROI and value to stakeholders as it now includes environment and people. It focuses on the broad and subjective results of measuring the investment growth from three perspectives—people, profit and planet. It is an evaluation methodology which includes the three segments of business's growth as social, environment and economic which can be difficult to measure appropriately (Bala, 2016). It is also referred to as the 3Ps (People, Planet and Profits).

The TBL (Slaper & Hall, 2011, p. 4) "*captures the essence of sustainability by measuring the impact of an organization's activities on the world… including both its profitability and shareholder values and its social, human and environmental capital*". The Triple Bottom Line is a framework used to measure the economic, social and environmental performance of an organisation (Fig. 1).

2.3.1 People

Social sustainability concerns maintaining the relationships with employees, consumers and society. The TBL Company takes step to ensure that its operations benefit employees as well as the community in which it conducts business. These companies contribute to the community through charity, education programs and employment equity (Measures, 2016).

2.3.2 Planet

Environmental sustainability concerns the effects on the environment of resource consumption, contamination and noxious emissions. It helps an organisation to identify the recycling resources, reduce risks and save costs by minimising the production of wastage (Heinberg, 2010). Companies avoid activities which harm the environment and control their energy consumption and reduce CO_2 emission (Measures, 2016).

Table 1 Sustainability development timeline (Bruce, 2017; Creech, 2012; BUSCO et al., 2017)—(Prepared by: Rajbir Kaur)

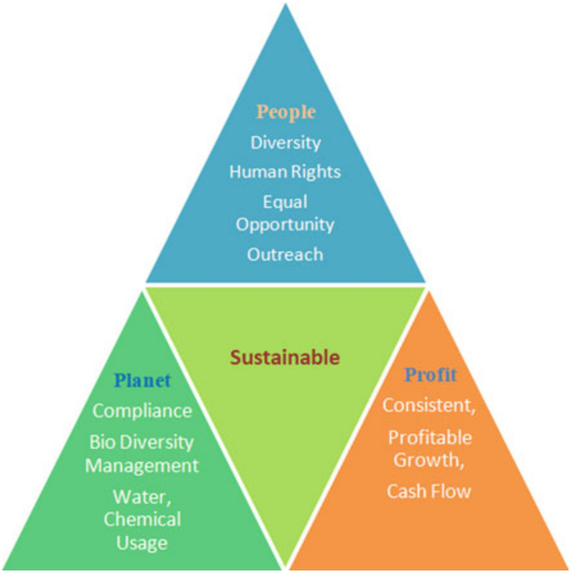
1962	Rachel Carson's book 'Silent Springs' pull attention to the environmental impacts of synthetic pesticides
1967	Environmental Defence Fund is formed to begin the legal solutions to environmental destruction
1968	Intergovernmental Conference for Rational use and Conservation of Biosphere (UNESCO, #45) was held
1969	Zager and Evans song 'In the Year 2525' was a protest song that predicted a depressing prospect for humanity's future
1970	First Earth Day held as a national teach-in on the environment
1971	Greenpeace started in Canada
1971	International Institute for Environment and Development (IIED) was established in U.K
1972	Club of Rome published the Controversial *Limits to Growth*
1973	Chipko Movement born in India
1974	Prof. Muhammad Yunus started the 'Grameen Bank' in Bangladesh to introduce micro-credit to the world
1975	The Convention on International Trade in Endangered Species of Flora and Fauna (CITES), came into force
1976	Habitat, the UN Conference on Human Settlement was the first global meeting
1977	Green Belt Movement started in Kenya
1978	Amoco Cadiz oil spill occurred off the coast of Brittney
1979	Three Mile Island nuclear accident occurred in Pennsylvania, US
1980	Global 2000 Report was released.
1981	World Health Assembly adopted the Global Strategy for health for All by the Year 2000
1982	World Resources Institute was established in US
1983	Development Alternatives was established in India
1984	Edward Freeman supported the stakeholders and challenged the concept of the shareholders as the prevailing voice of corporations
1985	Antarctic Ozone hole discovered by British and American scientists
1986	Chernobyl nuclear station accident caused massive toxic radioactive explosion
1987	The UN's Brundtland Commission report 'Our Common Future' endorsed for sustainable development
1988	Intergovernmental Panel on Climate Change (IPCC) was established
1989	Stockholm Environment Institute was established
1990	UN Summit for Children was held

(continued)

Table 1 (continued)

1990	International Institute for Sustainable Development (IISD) was established in Canada
1991	Hundreds of oil fires burned for months in Kuwait
1992	The Rio de Janeiro Earth Summit focused on the issues of sustainability. Agenda 21 was established. A 12-year-old child, Severn Suzuki presented a stirring message
1993	First meeting of the UN Commission on Sustainable Development was held
1994	John Elkington, a business consultant, coined the term 'Triple Bottom Line'
1995	Shell's disposal of the Brent Spar oil buoy caused widespread complaints that forced Shell to listen to its stakeholders and change its practices
1996	ISO 14001was formally adopted for corporate environmental management
1997	The Kyoto Protocol was adopted to control greenhouse gas emission
1998	Controversy regarding genetically modified organisms
1999	The Dow Jones Sustainability Indexes was launched
2000	The largest-ever gathering of world's leaders agreed on UN Millennium Development Goals to be achieved by 2015
2001	Fourth Ministerial Conference of WTO held in Doha, Qatar
2002	World Summit on sustainable development held in Johannesburg
2004	Delhi mandates the use of compressed natural gas in city buses and auto rickshaws
2005	Accountability launched the AA1000 Stakeholder Engagement Standard
2006	NASA reports that the Ozone Layer is recovering
2007	Better Place was established and emerged plans for the mass adoption of electric cars
2008	World food prices increase 43 percent in one year
2009	China overtakes the US as the World's largest emitter of GHGs
2010	The BP Gulf oil spill
2011	The Sustainability Accounting Standards Board (SASB) was formed to develop and distribute sustainability standards
2012	One of the first of the Millennium Development Goals is achieved by halving the number of people in the world without access to safe drinking water
2013	The International Integrated Reporting Council (IIRC) released its framework based on the concept of multi-capitals to support integration of financial and pre-financial data
2015	The UN General Assembly adopted the 2030 agenda for Sustainable Development with a list of sustainable development goals, comprising 17 objectives and 169 targets

Fig. 1 Triple Bottom Line (Bala, 2016). Prepared By: Rajbir Kaur



2.3.3 Profit

Economic sustainability is concerned with the efficiency, productivity and benefits of an organisation. An organisation must be operated without harming people and earth during development, production and building strategies for business (Heinberg, 2010). Economic measures use different variables to calculate TBL such as personal income, cost of underemployment, establishment blend, establishment sizes job growth, employment allotment by sector, percentage of enterprises in each sector, profits by sector contributing to gross state product (Slaper & Hall, 2011).

The 3Ps are crucial for sustainable growth, and the absence of one aspect may have severe effects on the others. So, the whole world should consider the importance of this Triple Bottom Line in order to achieve the sustainable goals.

2.4 CSR

CSR includes a variety of activities such as developing relationships with customers and employees, protecting the environment, working with local communities for sustainability etc.

There is no definition of CSR, although Canada defines CSR as:

> a company's commitment to operating in an economically and environmentally sustainable manner while recognizing the interests of its stakeholders. (Durand, 2006, p. 1)

On the other hand, the European definition of CSR is:

Fig. 2 Corporate social responsibility (GoC, 2015). Prepared By: Rajbir Kaur

> a new business strategy in which companies conduct business responsibly by contributing to the economic health and sustainable development of the communities in which they operate; offer employees healthy, safe and rewarding work conditions; offer quality, safe products, and services and provide a fair return to shareholders while fulfilling the above principles. (Durand, 2006, p. 1)

CSR is a broad notion that covers numerous aspects related to society and the environment including human resources, corporate governance, health and safety, working conditions, contribution to economic development, and environmental effects (Geethamani, 2017) (Fig. 2).

2.4.1 Why CSR?

There are several reasons why a company should adopt CSR as follows:

1. **Innovation**: Without CSR, companies might not be encouraged to research and develop these kinds of products. It is crucial to have new ideas and developments to run a business successfully and to survive in the era of competition (WhaleMarketing, 2015).
2. **Cost Savings**: Sustainability is one of the most effective ways of reducing costs. This can be done by reducing energy consumption, having less packaging etc.

According to the General Mills CSR Report 2011, this company saved $600,000 by reducing energy consumption by 20% (Reeves, 2012). If companies treat sustainability as a goal, businesses can create more competencies that can be very difficult for other firms to beat (WhaleMarketing, 2015).

3. **Brand Differentiation**: CSR has an impact on the brand differentiation by engaging employees and customers. If a company's CSR agenda is visible to the public, they will be attracted to the company's products (WhaleMarketing, 2015).
4. **Long-term thinking**: CSR should be adopted for the future growth of a company. The companies which think about long-term plans and initiatives can improve and secure their future (WhaleMarketing, 2015). CSR helps an organisation to stand in good stead in the present competition and grow in the future.
5. **Customer Engagement**: This is a tool for business-to-business communication. CSR motivates companies to engage with their customers in different ways (WhaleMarketing, 2015). In 2008, Walmart ran an ad campaign to make people aware of environmental issues and the choices that people could make when buying products. Walmart became the leader of environmentalism (Reeves, 2012).
6. **Employees' Engagement**: As a CSR priority, there should be sustainability strategies in a company to encourage employees to be involved in community services (WhaleMarketing, 2015). The companies should involve their employees in the decision-making process because if employees are not aware that what is going on in the company, it might be difficult to become successful.

2.4.2 Types of CSR

CSR assumes that the responsibility of business should not only be concerned with economic and legal matters, but also with the environmental, philanthropic, and ethical considerations as well. There are four categories of Corporate Social Responsibility.

1. **Legal Responsibility**: It is important to comply with the federal, state and local rules and regulations. Legal components include the commitment to be reliable with the government and laws. Companies need to produce the products and services that meet certain standards and legal requirements (Carroll, 1991).
2. **Philanthropic Initiatives**: This responsibility involves charity and donations to various causes at local, national or international levels. The various causes may be associated with education, a disease epidemic, unavailability of drinking water, natural disasters in undeveloped nations (Krohn, 2018). The philanthropic initiatives need to be consistent and aligned with society's expectations of a business.
3. **Ethical Business Practices**: Ethical business responsibility is concerned with fair trade practices. It comprises equal pay for equal work, equal rights, no exploitation etc. (Krohn, 2018). Companies can be ethically responsible by providing job opportunities for the unemployed, provide benefits to their employees, pay high wages, and ensure the employees' quality of life.

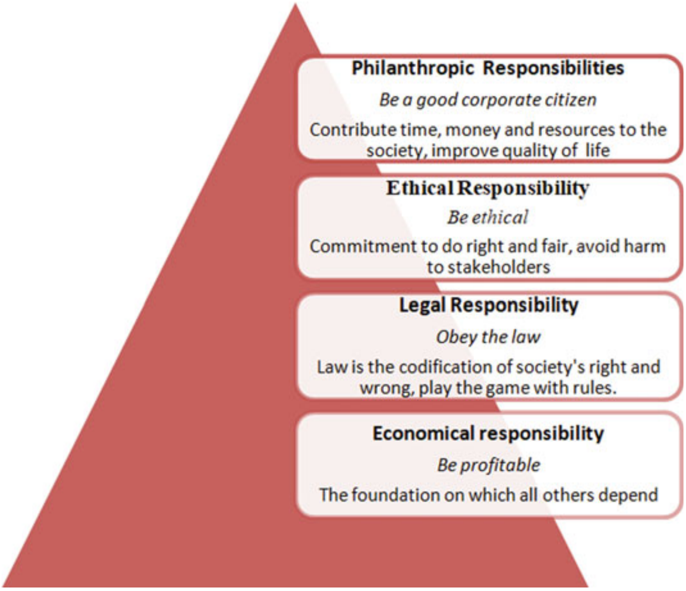


Fig. 3 The pyramid of corporate social responsibility (Carroll, 1991). Prepared By: Rajbir Kaur

4. **Economic Responsibility**: Economic responsibility includes the responsibility to grow the company by providing financial benefits while considering the environment, engaging in philanthropy and maintaining ethical standards (Krohn, 2018). The financial decisions of the company should have a positive impact on society as well as on the position of the firm (Fig. 3).

2.4.3 Roles of CSR

CSR plays a vital role in the running of a business in an effective and efficient manner. Some of its functions are:

1. CSR policy enables firms to think beyond the basic ethics to the benefits of involvement in community activities. This involvement helps companies to build long-term and trusted relationships with customers (Sen, Bhattacharya, & Korschun, 2006).
2. CSR helps companies to motivate their employees by providing fair wages, incentives, respect and good working conditions. It increases the morale of employees and improves teamwork.
3. CSR helps a company to be financially profitable (Chernev & Blair, 2015) and to safeguard the environment by introducing energy-efficient practices and waste recycling. CSR also improves company accountability and transparency by investing analysts, media, shareholders and local communities (Sharma, 2013).

4. CSR policy enables firms to show their true commitment by using sustainable material for production, donating money to charity for different purposes, paying for the participation of employees in charity activities (Sharma, 2013).
5. Social media plays a vital role in raising the awareness of people. Companies use social media for the visible CSR campaign to promote the fundraising programs and other societal development programs. This visibility helps firms to build a stronger relationship with its customers, increase brand loyalty (Chernev & Blair, 2015) and protect the brand.
6. When a company is socially responsible, it has positive public relations as well as strong relations with the government body and politicians. There are fewer inquiries into a company if the corporation works according to society's standards.
7. CSR helps to build a positive working environment for the employees. When employees are aware of the honesty, good position and true ethics of their company, they become more enthusiastic and engaged in work (Sharma, 2013; Doorn, Onrust, & Verho, 2017).
8. CSR activities help firms to increase their reputation. CSR enables them to acquire intangible resources from the stakeholder relationships (Ghoul, Guedhami, & Kim, 2017).

2.4.4 Advantages and Disadvantages of CSR

According to one study, companies that have adopted CSR achieved 19 times higher returns than the companies who do not have CSR commitment (Geethamani, 2017). Some of the benefits of CSR are listed below:

- CSR helps to stand against exploitation of labour, bribery and corruption.
- It improves the profitability, growth and performance of a company.
- CSR helps to attract new employees and increase the retention of workers.
- It creates a positive impact on community.
- CSR supports public value outcomes.
- It encourages professional and personal development.
- CSR boosts the company's image and reputation and helps to attract new capital inflow from other sources.
- When a company works within the CSR standards, the regulatory authorities become less antagonistic.
- CSR gives the company good publicity and acts as an advertisement for business.
- It improves the relationship between company and stakeholders, shareholders and employees (Geethamani, 2017; Muir, 2015; Kielmas, 2018; Mark, 2014).

2.4.5 Disadvantages of CSR

While CSR has social, economic and environmental benefits, CSR has several drawbacks as well.

- The large organisations can afford social media to communicate CSR policy to their customers, but this is not possible for small businesses. It may increase the cost of operations and production.
- 'Greenwashing' is one more disadvantage of CSR as some companies only talk about CSR but do nothing.
- There is additional bureaucracy with the mounting expenditure of scrutiny.
- Reporting criteria are different for different companies, countries and sectors.
- The legislation would increase the vocalization of critics that CSR in companies is only concerned with making profits.
- When a company becomes involved in CSR companies, customers want to see instant results, and when do not get any result; they think that the company is just doing a publicity stunt.
- CSR policy forces companies to reveal the deficiencies in their own products, thereby creating distrust in their customers.
- CSR shifts the company from the objective of profit making. The company effects the cash outflow and forgets the profit-making obligations to its stakeholders (Geethamani, 2017; Kielmas, 2018; Mark, 2014; Evans, 2017).

2.5 Sustainability in India

India is the third largest economy in the world, the second largest populated country after China and has a fast growing economy with 7.6% GDP growth rate (Eklund, 2016). It is the home of one-sixth of the world's people, but most of its population is living below the poverty line. Due to its rapid growth, size, bureaucracy and corruption, it is very difficult to achieve sustainability. The biggest challenge in India is air pollution as residents of India are dependent on coal which emits enormous amounts of CO_2. From late September through October of each year, farmers mainly in Northern India burn an estimated 35 million tonnes of crop residue to clean paddy straw from their fields. Due to that, in Delhi, the level of air pollution has risen 12–60% in 2017, creating a huge quantity of smog and poor air quality (Prakash, McGrath, Dolšak, & Bernaue, 2017). It caused several ailments ranging from premature birth to a decrease in lung immunity. Ten percent of wildlife is threatened, agriculture biodiversity has declined by 90% in some regions, and land degradation is increasing day by day due to the excessive use of fertilizers (Singh, 2017). The southern parts of India are facing drastic scarcities of drinking water, sanitation facilities, food and diseases. The people need to go long distances to get water for daily usage. Sometimes water tanks provide them drinking water.

However, India is a leader in the reduction of climate change and achieving SGDs. According to Lise Kingo, CEO and Executive Director of the United Nations Global Compact, "India is the land of opportunity for sustainable development. More than 50% progress towards achieving the sustainability goals will come from India". (The Hindu, 2017, p. 1). India has opportunities worth $1 trillion for companies work in sustainable areas and employment generation worth 72 million by 2030.

The government of India is taking initiatives to encourage company on the path of sustainability with the help of public and private organisations and international investments. India's development slogan, 'Collective Effort, Inclusive Growth', is helping the country to move towards achieving sustainability. In 2014, The Prime Minister of India Mr. Narendra Modi opted a 'Make in India' policy to invite industries to invest in India (IBEF, 2018). It will help the economic growth of India, reduce unemployment and improve living standards.

The government is directing industries to innovate and move to cleaner technologies. For this, Bharat Stage (BS) standards are modelled on the European emission standards for automobile emissions (Mohpatra, 2017). In 2013, the National Electric Mobility Mission plan 2020 (NEMMP) was established to increase the use and production of electric vehicles in India to improve national energy security, reduce the adverse impacts of transportation on the environment and increase the domestic manufacture of electric vehicles (Shukla, Dhar, Pathak, & Bhaskar, 2014). Electricity and low carbon fuel such as natural gases and biofuels are replacing the traditional fuels and technologies to reduce GHG and CO_2 emissions, and improve air quality.

The new Bangalore airport is the first airport built on a Greenfield site and was ready in thirty-three months. It received many certificates for environment friendliness and sustainability initiatives, such as GreenCo Platinum ranking (SN, 2016) and 'level 3+ Neutrality' under the Airport Carbon Accreditation programme for highest level of environment achievement (Roy, 2017). Airport Council International recognised it as the path to sustainable growth for its efforts to manage and reduce carbon emissions.

The 'Pradhan Mantri Jan-Dhan Yojana (PMJDY)' was launched as the largest financial institution to ensure access to banking facilities for everyone, access to need-based credit, remittance facility, financial literacy, one basic bank account for each household, insurance and pension for the weaker sectors and low income groups (GoI, 2014). It was one of the initiatives towards achieving the no-poverty sustainable development goal to reduce poverty and hunger by providing financial help to the population.

Another initiative for environment cleanliness in India is the 'Clean India Mission' run by the government of India to clean up 4,041 cities and towns all over India. The main objectives include cleaning the rivers, streets, roads, promoting sanitation programmes in rural areas, solid waste management and changing the infrastructure of the country to lead the country forward (PMINDIA, 2014). It is achieving great success as literacy, awareness and participation of people in every sector of society is increasing.

The water and waste management industries of India are shifting towards ensuring the cleanliness of water by recycling and reusing water, having zero liquid discharge and using online effluent monitoring systems. Some of the major projects such as Ganga River Cleaning Project, National Hydrology Project, Groundwater Aquifer Mapping and Management Project and Smart Cities Initiatives (AusGovt 2017) have been launched to save water and energy, recycle and reuse waste water, urban water supply, restoration of rivers, flood management, proper sewage management and monitoring of underground water.

Businesses and organisations are also taking initiatives to make the India more sustainable. There are numerous examples of business initiatives taken by businesses such as Ashok Leyland that saved 35–40% energy, Infosys reduced 23% of energy consumption, and Hindustan Unilever Limited which reduced its water usage by 53%, wastage by 45% and CO_2 emissions by 42% (HUL, 2018) to name just a few. In addition, P&G started sustainable product innovations in different ways from product design to packaging. This group has adopted various strategies to transform 575 tonnes of scrap material into products for daily use. For instance, plastic is recycled to make chairs, metal laminate can be mixed in with cement for construction, 380 tons of waste from shampoo production is used for car washing, and 5.5 tons of skincare manufacturing waste is used in polishing material. It reused 4400 tonnes of scrap material, saved 13.3 million litres of water in 2017 and reduced the annual energy consumption by 27% over the last nine years (P&G, 2018). All these advancements are helping India to achieve sustainability and development faster and in well manner.

The PSS (Private Sustainability Standards) are market-based tools used to ensure sustainable production and business practices. These are complementing mandatory regulations to promote quality and safety. In addition to national regulations, voluntary measures that affect Indian production need to be considered. The Indian voluntary standards such as Trustea, INDGAP, ZED, and Voluntary Certification Scheme for AYUSH Products, Lead Safe Paints, and Medicinal Plant Produce claim to ensure long-term sustainability of supply chains, prepare markets for consumer awareness and demands of environmental safety, improve the competitiveness of industries, enhance the lifestyle of employees and improve production practices of small businesses (Pandey, 2017). By following these PSS, India can attract international investors and businesses by proving its commitment to sustainability.

The SDG Philanthropic Platform was launched in 2014 to promote sustainable development in India. This platform connects and catalyses partnerships organisations, grantees, partners, government, the UN System, academia and broader business communities to enhance the achievements of Agenda-2030. The main work of this platform in India is concerned with ending poverty, ensuring inclusive, empowerment of women, quality education, gender equality, promoting inclusive and sustainable economic growth and employment for all (RPA, 2016).

2.5.1 What Does Sustainability Mean for Business/Education in India?

Sustainability for Education

The Government of India has instructed its numerous education institutions to include environment units in their curricula to promote the value of sustainable development in education. In the early 1980s, the Ministry of Environment and Forests adopted this strategy post-1972 Stockholm Conference by setting up the Centres of Excellence for Environment Education. Later, it was recognised that a single ministry could not handle the overall country's education; as a result, the Ministry of Human Resource Development was established to incorporate environmental issues in all fields of education.

India is the first and only country to pass one of the landmark judgements of the Supreme Court to direct all education boards to include Environment education as a mandatory subject at each level of education. There are many other government and non-government bodies that are working besides the ministries of GOI to promote the ESD and work with the youth of the country and educational institutes to provide training and awareness of sustainability to students and the staff as well. The organisations include:

- Centre for Environment Education (CEE) which implemented UNDESD in India
- The Energy and Resources Institute (TERI)
- Bharati Vidya Peeth (BVP)
- Centre for Science and Environment (CSE)
- Worldwide Fund (WWF)
- National Council for Science Museums (NSCM)
- National Council of Education, Research and Training (NCERT)
- Indian Institute of Human Settlements (IIHS).

Advanced ICT (Information, Communication, Technology) tools were developed to connect with a large audience (Singh, 2015). The concept of green campuses can be fulfilled by reducing the carbon footprints, and by educating the people to reduce the wastage using the 3R (Reduce, Reuse and recycle) model.

The main objectives of higher education institutions include promoting awareness of sustainability, sharing knowledge about ecological issues and solutions, deploying new eco-friendly technologies to make campuses green and clean, and encouraging research in the field of sustainability. Some of the Indian universities and colleges that have taken initiatives towards sustainable education are listed in Fig 4.

Sustainability in Business

Indian businesses have just considered the concept of sustainability and its advantages in terms of trade; only a handful of companies are reporting sustainability information. The trend of reporting voluntary sustainability information is growing rapidly day by day. From 2007 to 2011, under the Carbon Disclosure Project, the reporting by Indian organisations has increased by 33%. Moreover, Global Initiative Reporting received sustainability reports from 88% Indian companies. In 2013, Newsweek ranked 13 Indian corporations among the world's 'greenest' companies. Three of those were ranked in top 20; the companies were Wipro in 3rd place, Tata Consultancy Services was ranked 11th and Infosys was placed at 19th position.

Some examples of Indian companies which have incorporated sustainability practices into their businesses are:

- The truck manufacturing company, Ashok Leyland, saves 35–40% energy in their LEED-certified office building.
- Shoppers Stop saved INR 440 lakhs in the first year of implementing energy saving systems.
- Since 2008, Infosys has reduced energy consumption by 23% per campus all over India (Chacko, 2013).

Fig. 4 Sustainable universities of India (Mahajan & Bist, 2014; Javedkar, 2017). Prepared By: Rajbir Kaur

- Hindustan Unilever Limited reduced water usage by 53%, wastage by 45% and CO_2 emissions by 42% in 2016 compared to 2008 (HUL, 2018).
- Mahindra Group of Automotive manufacturers introduced the hybrid and electric cars in India and also initiated materiality studies and 'water positive status' to save on water consumption (Manoukian, 2016).

Other companies such as LG, HCL, Haier, Samsung, Tata Consultancy services, Oil and natural Gas Company, Induslnd Bank, ITC Limited, MRF Tyres have taken sustainable initiatives to save energy, reduce carbon emissions, enhance quality of life, conserve water and ensure a green future (Choudhury, 2016).

IIM Udaipur conducts The Responsible Business Ranking Study every year to analyse the company's performance of sustainability and CSR parameters. The study is based on four categories: Governance, Disclosure, Sustainability and Stakeholders having weights of 20%, 15%, 35% and 30% respectively (Majmodar, Rana, & Sanan, 2018). Table 2 lists the top 15 companies of India in terms of sustainability and CSR ranking in 2017.

2.6 Advantages and Disadvantages of Sustainability

This section will discuss the advantages and disadvantages of sustainability see Figs. 5 and 6.

Table 2 India's top companies for sustainability and CSR 2017 (Majmodar et al., 2018; IndiaCSR, 2017). Prepared By: Rajbir Kaur

Rank	Company	Rank	Company
1	Tata Chemicals Ltd.	11	Coca-Cola India Pvt. Ltd.
2	Tata Steel Ltd.	12	Bharat Petroleum Corporation Ltd.
3	Tata Power Company Ltd.	13	Infosys Ltd.
4	Shree Cements Ltd.	14	Cisco Systems India Pvt. Ltd.
5	Tata Motors Ltd.	15	Reliance Industries Ltd.
6	Ultra Tech Cement Ltd.	16	Larsen & Toubro Ltd.
7	Mahindra & Mahindra Ltd.	17	Indian Oil Corporation Ltd.
8	ACC Ltd.	18	Hindustan Unilever Ltd.
9	Ambuja Cement Ltd.	19	HCL Technologies Ltd.
10	ITC Ltd.	20	Hindustan Zinc Ltd.

Fig. 5 Advantages of sustainability (Issa, Isaias, Issa, 2017; Weybrecht, 2010). Prepared By: Rajbir Kaur

3 Research Methods and Research Questions

The primary research question that is addressed in this study is:

What are the advantages and risks associated with the sustainability adoption in Indian society?

To answer this question, an online survey was distributed among people in India. The attitudes and behaviours of people were determined to discover their awareness level regarding the advantages and disadvantages of sustainability in their personal and professional lives.

The qualitative research method was used to collect the data to study the awareness of sustainability in Indian society because this study is related to human views, thinking, experiences and feelings. An online survey was conducted and distributed

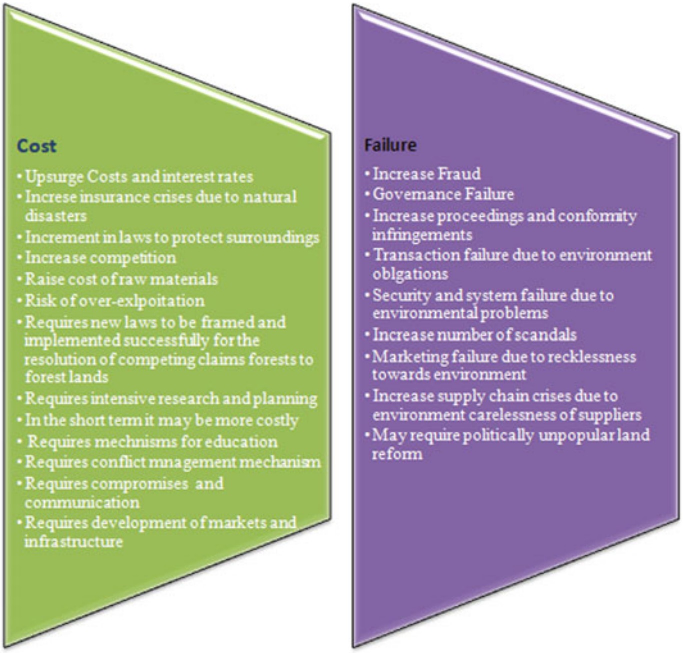


Fig. 6 Disadvantages of Sustainability(Issa et al., 2017; Issa, 2017). Prepared By: Rajbir Kaur

among the Indian people via various online platforms such as email, Whatsapp, Facebook, Messenger, LinkedIn and texting to the people living in India and working in the public and private sectors. The Qualtrics tool was used to create and distribute the online survey. A database was created to store the survey responses in order to collect data easily and efficiently. The survey questionnaire consisted of different three parts. The first part was intended to gather demographic about the participant such as age, gender, occupation, education and how they came to know about the term 'sustainability'. The next section was concerned with participants' usage of electronics. It contained questions about when, why and for how long they used the internet, emails, social networks, how often they change their devices, the reason for changing devices, and their awareness of the device sustainability rates. The last part concerned the sustainability risks and advantages. The collected data was then analysed to know participants' level of awareness of sustainability. To determine the level of awareness about sustainability, Indian people were used as unit of analysis. After collecting the data, each unit like age, gender, job, education, use of smart devices and technology was analysed to get the vast information needed to do accurate and relevant research. A 5-point Likert scale was used in third part of questionnaire. The Likert Scale is used to measure the elements that cannot be counted. Some questions can only be answered through feelings, emotions and personal views. The Likert scale consisted 5 options ranged from strongly disagree, disagree, neutral, agree and strongly agree. It was used to observe that how many respondents are strongly agreed or disagreed about the advantages and disadvantages of sustainability. The results of this study were presented numerically. This research was independent of the researcher's view and followed unit analysis of survey.

In this research, the deductive approach (quantitative approach) was used to generate the hypotheses from theory and then the conclusions were analysed and verified by using various tools.

The target population of the current research was Indian people aged 17–65 years who are educated and employed. Those targeted for the survey had access to the internet and smart devices and understood the main purpose of the survey. A total of 190 people participated in the survey, but only 111 surveys were fully completed. Both male and female participants were targeted. The SPSS software was used to arrive at consistent and constructive conclusions. The survey was sent to many people but not all the respondents filled the survey completely. Hence, the incomplete surveys were excluded to ensure that the results are reliable and valid.

4 Results

The evaluation of the online surveys was done to produce the statistics from the gathered data. In total, 190 surveys were distributed via the internet. To obtain accurate results, 111 surveys were analysed.

Of those who participated in the survey, 47.9% were male and 52.1% were female. The Cronbach's Alpha, KMO and Bartlett's tests were conducted on the collected data to check them for reliability and excellence. In total, 37 items were analysed to produce the reliability statistics. The Cronbach's alpha for advantages and risks is shown in Table 3. According to the rules of thumb for alpha, both results are excellent.

Another test, known as the KMO test, was conducted to measure sample adequacy (Table 4). KMO and Bartlett's Test of Sphericity were conducted to measure the suitability of respondents' data (Williams, Brown, & Onsman 2014).

For this study, the Exploratory Factor Analysis was done to generate new advantages and risks from a large set of items. The Principal Component Analysis (PCA) method was used to extract the factors. The rotation of factors was done to make the structure of items more straightforward. It is used transfer the high load items in one

Table 3 Cronbach's alpha Prepared By: Rajbir Kaur

	Reliability Statistics	
	Cronbach's Alpha	No. of Items
Advantages	.925	24
Risks	.934	13

Table 4 Results of KMO measure of sampling adequacy and Bartlett's test of sphericity Prepared By: Rajbir Kaur

Approaches	Kaiser-Meyer Olkin	Bartlett's Test of Sphericity		
	Measure of Sampling Adequacy	Approx Chi-Square	Df	Sig.
Advantages	.847	1291.002	276	.000
Risks	.882	926.217	78	.000

factor and low load items on another factor to produce an easy and interpretable solution. This study used the orthogonal varimax technique to produce the uncorrelated factor structure. Table 5 shows the factor analysis for advantages.

Table 5 Factor analysis for advantages Prepared By: Rajbir Kaur

Rotated Component Matrix[a]		
	Component	
	1	2
Reduce health hazards	.717	.160
Create new jobs	.709	.139
Reduce energy and water usage	.688	.255
Increase green strategy	.685	
Attract new opportunities	.654	.248
Reduce emissions	.651	.339
Reduce pollution	.645	.283
Reduce consumption of raw materials	.634	.245
Reduce paper usage	.611	.163
Improve human rights	.596	.219
Improve community investments	.558	.310
Increase efficiency	.519	.309
Enhance reputation	.474	.457
Increase triple bottom line – People, Planet and Profit	.465	.394
Satisfy customer needs	.122	.757
Differentiate businesses		.688
Attract quality employees	.201	.685
Improve corporate social responsibility	.220	.683
Increase productivity	.146	.572
Reduce carbon footprint	.392	.562
Meet stakeholder expectations	.236	.534
Improve social responsibility investing	.371	.500
Increase cost-effectiveness	.380	.481
Reduce risk management	.365	.449
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization [a]		
a. Rotation converged in 3 iterations		

Table 6 New generated factors for advantages Prepared By: Rajbir Kaur

Variables	Factor Loading	New Factor
Reduce health hazards	.717	Reduce harmful effects
Create new jobs	.709	
Reduce energy and water usage	.688	
Increase green strategy	.685	
Attract new opportunities	.654	
Reduce emissions	.651	
Reduce pollution	.645	
Reduce consumption of raw materials	.634	
Reduce paper usage	.611	
Satisfy customer needs	.757	Sustainable Business
Differentiate businesses	.688	
Attract quality employees	.685	
Improve corporate social responsibility	.683	

Table 6 illustrates the new factors that were generated from the group of items after extraction of factors. The factors ranged from 0.717 to 0.611 are considered as values that will help to produce new advantages of sustainability based on Indian users' responses. The items with factor loadings from 0.757 to 0.683 were considered to produce another factor for advantages.

4.1 Factor Analysis for Risks

Table 7 presents the rotated component matrix for disadvantages of sustainability.

The variables within the range of 0.844–0.661 were selected to generate a new factor, and items with loadings of 0.843 to 0.614 were used to create another factor for risks. Table 8 shows the new generated terms for the risks of sustainability by selecting a group of items from the survey based on the responses of Indian people.

4.2 Conclusion from Analysis

The analysis provided new terms and insights in the field of sustainable growth. The new advantages and risks generated from the analysis are shown in Fig. 7 (Figs. 8 and 9).

Table 7 Factor analysis for risks Prepared By: Rajbir Kaur

Rotated Component Matrix[a]		
	Component	
	1	2
Increase governance failure (including environmental actions and environmental compliance failures)	.844	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	.818	
Increase fraud (including environmental actions and environmental compliance failures)	.732	.217
Increase marketing failure by perceived environmental irresponsibility	.701	.414
Increase transaction failure due to environmental liabilities	.696	.358
Inflate costs	.663	.410
Increase supply chain crises due to suppliers' environmental problems	.661	.427
Increase scandals by perceived environmental irresponsibility	.595	.538
Increase insurance crises due to environmental disasters	.591	.468
Increase interest rates	.559	.472
Increase competition for and cost of raw materials		.843
Increase number of new regulations including environmental	.244	.797
Increase security and systems failures caused by environmental problems	.500	.614
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization		
a. Rotation converged in 3 iterations		

5 Discussion, Future Research and Limitations

The main objective of this research is to discover the level of awareness regarding sustainability among Indians and whether this is determined by their age, gender and their educational level. This study is important in terms of alerting people to the need to become more sustainable. It will be helpful to learn about the pros and cons of sustainability. It will help people to use sustainable strategies and policies in their business and personal lives to save the planet, to secure society and derive financial benefits for themselves and the relevant stakeholders. This research also has significance in real life and contributes to the literature. The field of sustainability has attracted very limited attention from researchers. This study helps future researchers to acquire more knowledge about sustainability, and the pros and cons of sustainability. If anyone wishes to study the same issue in the Indian context, this research

Table 8 New generated factors for risks Prepared By: Rajbir Kaur

Variables	Factor loading	New Factor
Increase governance failure (including environmental actions and environmental compliance failures)	.844	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	.818	
Increase fraud (including environmental actions and environmental compliance failures)	.732	
Increase marketing failure by perceived environmental irresponsibility	.701	Breach of Laws
Increase transaction failure due to environmental liabilities	.696	
Inflate costs	.663	
Increase supply chain crises due to suppliers' environmental problems	.661	
Increase competition for and cost of raw materials	.843	
Increase number of new regulations including environmental	.797	Increase Cost
Increase security and systems failures caused by environmental problems	.614	

Fig. 7 The new generated risks and advantages. Prepared By: Rajbir Kaur

will be very helpful to them. It has facts and data that show the awareness level of people, and researchers can use this data as secondary data in their own work.

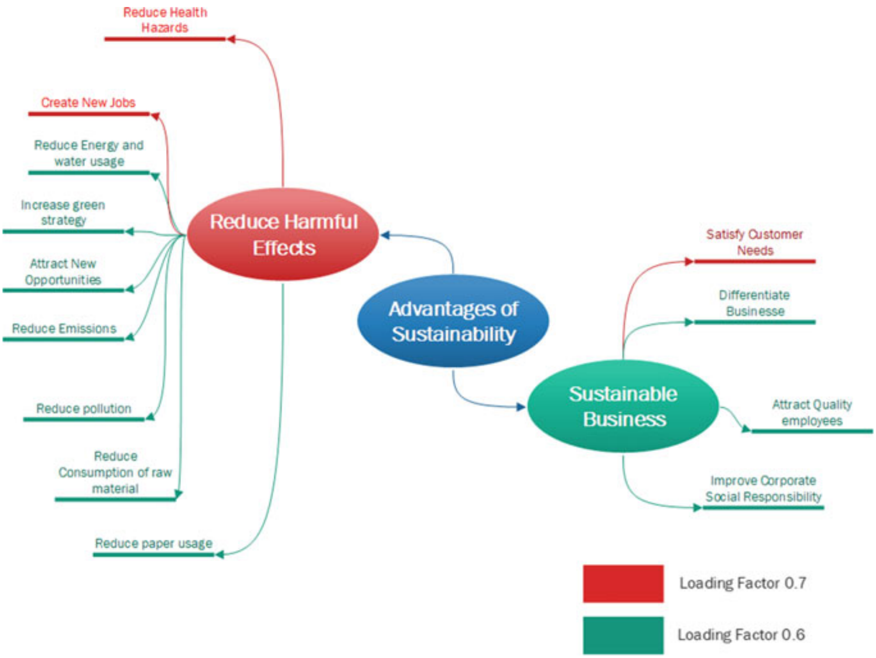


Fig. 8 Analysis of findings for advantages. Prepared By: Rajbir Kaur

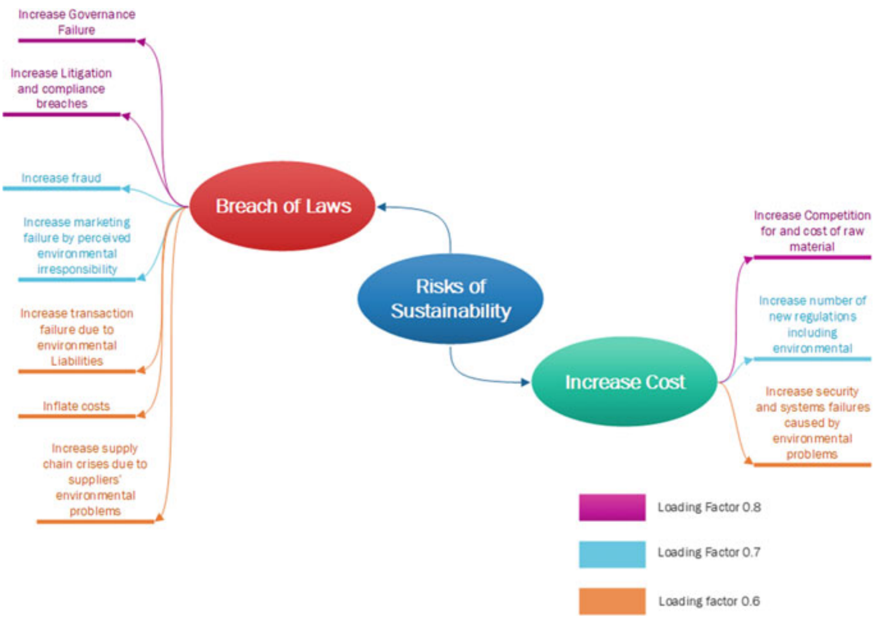


Fig. 9 Analysis of findings for risk. Prepared By: Rajbir Kaur

5.1 Future Research

This research concerns the advantages and disadvantages of sustainability awareness in Indian society. This issue provides a vast scope for related study in future. Further studies can be conducted on a broader sample of the Indian population, since this study gathered data from a specific area of India and the time constraint prevented the collection of data from a larger sample. Researchers can use the findings of this study as secondary data as it is real and accurate. Future studies can use this research to compare the advancements and downsides related to sustainability in the future. They can determine whether the trend toward sustainability is increasing. Academics can conduct studies to compare the sustainable development all around the world. They can compare the sustainability initiatives between developed and developing countries.

5.2 Limitations

There were some limitations faced by researcher in terms of time, focus, area and sample size. Some of the limitations are described as follows:

- The focus of this study was limited to a small set of data as the survey was distributed among potential participants in a small region of India.
- The literature related to sustainability in India was also limited.
- The size of the sample was very small as only 111 people responded to the surveys.
- The Indian public is not very aware of sustainability, so it was very time consuming and tedious to explain some terms to the respondents.
- There was also the lack of face-to-face communication between the participants and the researcher. The survey was done in different geographical areas, so the accessibility and lack of physical presence of the researcher were also impediments to the research as people were not very interested in completing the survey as it was sent to 190 people but only 111 people completed it.

5.3 Recommendations

After analysing the results obtained by this study, it is evident that there is a great need to understand the term ‘sustainability’ properly. It is essential to understand the importance of sustainable growth. As India is facing numerous barriers in the area of sustainability due to development, it is time to take some initiatives to reduce the degradation of nature. The first and initial step is awareness. People need to be aware of the hazardous effects and the solution to mitigate those risks. The awareness can be spread via the internet, T.V., social networking, seminars, education, training, researches, and campaigns, among others. The attitudes of people can be changed only with knowledge. Furthermore, businesses and organisations must be more responsive towards their actions; they need to be answerable for their products, services and operations. Firms should not think about financial gains only; they also need to think about society and the natural environment. Moreover, to make the younger generation more aware of sustainability, a unit related to sustainability should be included as a mandatory subject in all fields of education.

6 Conclusion

This research was conducted in order to discover the awareness level of the Indian public regarding the issue of sustainability. It also discussed the advantages and risks associated with sustainability that were generated after analysing the results. The findings were discussed and analysed later for better consideration of the study. The findings show that people have a general understanding of how to protect the environment. But in terms of technology and electronic devices, they are not very concerned about the harmful effects of using the devices in excess. They seem to have little idea about reducing, recycling and reusing electronics and IT devices. For some people, sustainability was a new term. It also discussed the limitations of the study: the time constraint and the sample size which prevented a more comprehensive exploration of the issues. Future research may be able to address the limitations of this paper and the research gap. It also provided some recommendations in order to increase sustainability. At the end, it is not only the responsibility of government organisations, NGOs and private sectors to save the natural environment; everyone should start taking initiatives at individual level, because small steps can make a big difference.

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The Cotton Value Chain: Improving Its Sustainability, Inclusiveness and Value Adding Capabilities: Italy-Egypt Collaborative Sustainability-Based Innovation

Dalia Gallico

Abstract In response to the challenges posed by sustainable development, and in line with the 2030 agenda which promotes the multi-stakeholder approach as one which can help to achieve the Sustainable Development Goals (SDGs), the project seeks to promote inclusive and sustainable development of the textile industry and increase the cotton sector's contribution to the Egyptian economy, employment and manufacturing value added and export growth. This will be done by actively engaging the private sector (CSR, investors, partners, mentors, etc.), developing business partnerships, and leveraging non-traditional funding. Moreover, as the proposed project puts the promotion of sustainable and inclusive growth at the centre of its action, particular emphasis is placed on addressing economic and social inclusiveness and active involvement of vulnerable groups (poor, women, youth, rural communities). The project will help to improve the farming environment (non-toxic and biodiverse), develop sector-specific technical and entrepreneurial opportunities, and capture business opportunities in national and international markets, thus contributing to better and more secure livelihoods for target beneficiaries and their households. Final consumers, in national and international markets, will also benefit indirectly from the proposed project as a result of efforts to preserve the quality and sustainability of Egyptian cotton and strengthen its competitiveness. Important innovation resulting from the collaborative partnership of Egypt and Italy will create new scenarios and concept design.

Keywords Sustainable development · Sustainable agriculture · Education · Active involvement · Environment · Textile · Cotton

1 Introduction

Cotton is the world's oldest commercial crop and one of the most important fibre crops in the global textile industry. It is grown in more than 100 countries on 2.5% of the world's arable land—some 35 million hectares—making it one of the most

D. Gallico (✉)
Università San Raffaele Roma, Rome, Italy
e-mail: dalia.gallico@uniroma5.it

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significant crops in terms of land use after food grains and soybeans. Cotton is also a heavily traded agricultural commodity with over 150 countries involved in exporting or importing it.

Cotton plays a major role in the economic and social development of developing and newly industrialized countries. There are millions of people worldwide who derive their livelihood from cotton's value chain, which involves several stages: research and development, cultivation, extraction of fibres, primary processing of the fibre for marketing, secondary processing of the fibre to yarn, dyeing and other processing to convert the yarn to fabric, and manufacturing clothes and other items. Furthermore, millions of people are employed in the associated activities of trade and transportation. As many as 100 million rural households—90% of them living in developing countries—are directly engaged in cotton production. An estimated 350 million people work globally in the cotton sector when family labour, farm labour and workers in connected services such as transportation, ginning, baling and storage are taken into account. The global garment and textile industries alone employ 60 million to 75 million people worldwide.

The cotton and textile industries play a significant role in the Egyptian economy. Egyptian cotton has historically represented the gold standard for the world's finest linens and clothing. Egypt's extra-long staple cotton (*Gossypium barbadense*), often called "White Gold", is grown in the moist atmosphere near the Nile. Egyptian cotton is among the finest and most lustrous varieties and the highest quality fibre. This quality is due to several factors. First, Egyptian cotton is generally handpicked in order to avoid mixing the yield of mature and immature plants. Secondly, it has exceptional length and brightness. The longer the fibre, the better the textile quality as it means less breakage and more uninterrupted thread. Therefore, the Egyptian cotton is widely used by luxury and upmarket brands.

Egypt's textile industry has historically been considered of paramount importance to the country and its economy. Currently, the Egyptian textile industry contributes to 3% of the country's GDP, accounts for one third of the manufacturing value added, employs almost one third of Egypt's industrial workforce, and constitutes 15% of Egypt's non-oil and gas exports (worth 2.6 billion USD).

Nonetheless, as recently stated in "Vision 2025 Expansion & Employment—Egypt textile National strategy", Egypt still plays a marginal role in the global textile value chain as its textile industry is highly fragmented and its textile products do not meet the needs and requirements of the international market.

Despite the efforts made by the Egyptian Government in recent years, the situation with regard to both the competitiveness of the Egyptian lint cotton and readymade garments remains critical. The industry suffers from lack of renovation, high input prices, limited skilled labour, and limited innovative and sustainable agricultural practices.

Spinning and weaving are the main sectors of the textiles industry. Most of the spinning and weaving firms are owned by medium- to large-scale public-sector companies, although the private sector is slowly entering this sector. Dyeing and finishing are the weakest points in the value chain, with the least amount of investments. The public-sector dominance of spinning and weaving has limited producers' responsiveness to consumer preferences and burdened the sector with over employment, inferior technology, operational inefficiencies, and low levels of capital utilization. Moreover, linkages between spinners and ready-made garment producers are weak at best.

As a result, some yarns and finished fabrics are imported from India, Turkey, Turkmenistan, Bangladesh, Pakistan, and other countries to supply the ready-made garment industry. Some finished fabrics are made of Egyptian cotton, processed abroad, and re-exported to Egypt.

Egypt exports long staple (LS) and extra-long staple (ELS) cotton, as well as garments (52.8% of exports) mostly using imported yarns, and finished fabrics and home textiles (25.4% of exports) made from local yarns/fabrics. 75% of raw cotton exports are sent to low cost, textile countries (e.g. India, Pakistan, China) where raw cotton is processed into added-value yarns, fabrics, garments (e.g. 100% Egyptian cotton shirts are made in India). Egypt imports relatively cheaper medium staple types for the textile and clothing industry.

The public-owned companies have been unable to compete with imported materials and products, losing market shares. As a result, many firms have declined, shutting off several production lines.

Egypt, that had initially seen an increase in area and production from the 1940s to the 1970s, has experienced a gradual production drop since the 1980s as well as a gradual decrease in consumption as customers shifted to cheaper, lower-quality fibre and fabrics like polyester. A substantial decline occurred in domestic sales and exports alike. As a consequence, and in light of the difficulties of marketing domestic cotton crops, thousands of Egyptian farmers have turned away from cotton in favour of other crops for both domestic markets and export. With the steady increase in imports (clothing, dyes and supporting material for the industry) compared to exports, the result was an overall negative trade balance. The textile and clothing industry began to drain foreign exchange resources rather than being a source of income.

2 Cotton Production in Egypt

The decline in production is strongly related to the decrease in foreign demand. The decline in exports of lint cotton is due to the perceived degradation in quality, both in terms of seed impurity and cotton lint contamination. Both cleanliness and contamination are determined by harvesting methods, handling, storage, transport and ginning practices. Contamination of lint by non-vegetable substances is one of the major problems, especially with handpicked cotton. Moreover, contaminated cotton causes disruptions in the spinning process; hence, such cotton is normally sold at a considerable discount to compensate the spinning company for the additional costs incurred.

Organic cotton accounts for a very small percentage of the overall cotton production in Egypt, despite the competitive advantage offered by the country's highly favourable natural environment and the potential benefits and profitability of penetrating the growing niche market of sustainable agriculture. The global demand for organic cotton has been steadily growing in the last years as an increasing number of brands have made commitments to use 100% organic cotton by ambitious target dates, often 2020. In order to benefit from this international trend, Egypt would need to establish a more sustainable and integrated supply chain starting with raw materials and fibre production, in addition to actively promoting and sustaining new and innovative business models by fostering collaboration between big and small brands, local producers and national and international mills.

In an effort to restore international market confidence in the quality of Egyptian cotton, the Government of Egypt has recently undertaken relevant normative reforms, namely: (i) the Ministerial decree number 1918/2015, which identifies the conditions for qualifying seeds for planting and reintroduced the Government full ownership of seed production and distribution, and the establishment of a monitoring system covering the entire supply chain of licensed Egyptian cotton holders under the umbrella of the Cotton Egypt Association (CEA). In addition, the Government, through the Cotton Research Institute, has planted selected cotton seeds from high quality lint in an area of 12,600 ha in eight governorates which produced 41,237 bales of cotton. The Ministry of Agriculture and Land Reclamation (MALR) declared its intention to conduct another round of seed purification to improve the quality and expects that around 60% of the seeds produced are going to be used for the 2019/20 crop. Despite the forecasted total increase, production of ELS is expected to continue its downward trend.

3 Cotton Industrial Transformation in Egypt

While Egyptian cotton is famous worldwide for its long staple, which allows it to be spun and woven into luxurious fabrics, getting full value from the long staple cotton requires updated and sophisticated technologies. However, most of Egypt's textile factories are equipped with outdated machinery not suitable for the processing of Egyptian ELS cotton. Indeed, the consumption projection for the year 2019/20 estimates a consumption of lint cotton equal to 590,000 bales and local spinners are expected to obtain 70% of their cotton requirements from imports and the remaining from local cotton production.

Coupled with the above-mentioned challenges is the lack of skilled human resources. In spite of the ongoing efforts of the Government of Egypt and the international community, notably through the EU TVET initiatives (I and II), to revamp and update the Technical and Vocational Education and Training System, there is still a substantial mismatch between the education system's outputs and the labour market requirements. According to the Annual Global Competitiveness Report 2015–2016 released by the World Economic Forum, Egypt ranks 131 out of 140 nations for the overall quality of its education system (with similar rankings for math/science and management education), and 117 for innovation.

This persistent dearth of skilled workers and general managers is particularly evident in the industrial and agricultural sectors. There is, in fact, a clear lack of horizontal integration between the agricultural and the industrial training path, resulting in a misperception of the complex interaction of the different actors of the cotton value chain, as well as a tendency to the segmentation of knowledge and limited coordination between education institutions and market operators.

Building on the continuous support received by UNIDO on promoting industrial development and on recent achievements related to employability, value chains and private sector development, the Ministry of Trade and Industry requested that UNIDO extend the collaboration to support the textile value chain.

Given the above scenario and in line with its mandate of promoting industrial development for poverty reduction, inclusive globalization and environmental sustainability, UNIDO is proposing the implementation of the project "From cotton seeds to clothing: Enhancing the sustainability, inclusiveness and value addition of the cotton value chain in Egypt", the objective of which is to improve the economic, social and environmental performance of cotton growers and processors while strengthening support institutions.

The proposed project has been designed to build upon the ongoing CSR initiative "Cottonforlife", implemented by FILMAR S.p.A. in collaboration with Alexbank, to further integrate the scope of intervention and scale up the impact of the Cottonforlife Initiative in order to upgrade the whole value chain, reach out to a larger number of producers and exporters, and expand the capacities of the institutions involved.

Cottonforlife is an integrated five-year program aimed at promoting sustainable fashion through transparent, eco-friendly and socially responsible Egyptian cotton textile production. The Initiative has managed, through signed agreements between the private sector and farmers' associations, Ministry of Agriculture and Ministry of Education, to initiate plantations of organic ELS Egyptian cotton (Giza 45 and Giza 87). It has produced a unique and extra-fine organic yarn, called NILO, which has been presented at the most important international fairs and has received acclaim from international buyers and most of the renowned Italian brands. The Initiative has also invested in the development of human resources, through an earmarked co-funding by Alexbank which has committed to supporting the initiative for five years, by assisting agricultural and industrial textile schools to improve the horizontal integration of the agricultural and the industrial training sectors. Activities implemented ranged from curricula development to training of trainers and publication of updated textbooks for the three—year course school paths.

4 Main Target Groups

The project seeks to propose and pilot innovative and sustainable solutions to address the various gaps and shortfalls along the whole LS and ELS cotton value chain. The project's activities will involve the following target groups, extending to at least 1,000 direct beneficiaries:

- Cotton growers and cotton growers' associations, that will benefit from knowledge sharing and capacity building with regards to the adoption of sustainable agricultural practices for organic and non-contaminated cotton and better market linkages;
- Private sector textile enterprises including SMEs and youth-led start-ups (involved in spinning, weaving, knitting, dyeing and/or finishing, garment manufacturers), whose productive and export capacity, social and environmental performance will be enhanced;
- Traders and retailers, who will benefit from improved practices in terms of product certification and traceability mechanisms as well as from better coordination and exchange of information between national and international actors;
- Agricultural workers as well as technicians and professionals employed in textile enterprises, whose skills will be enhanced to meet labour market needs, through updated educational and training programs and on-the-job training;
- Students enrolled in secondary technical agricultural and industrial schools and/or attending vocational training programs, whose skills will be enhanced to meet labour market needs, through updated educational and training programs and on-the-job training;
- Technical support institutions and specialized centres, which will benefit from the exchange of expertise and capacity-building activities.

Moreover, since the promotion of sustainable and inclusive growth is central to the project, particular emphasis is placed on ensuring economic and social inclusiveness and the active involvement of vulnerable groups (poor, women, youth, rural communities). It is anticipated that the project will improve the farming environment (non-toxic and biodiverse), develop sector-specific technical and entrepreneurial opportunities, and capture business opportunities in national and international markets, thereby contributing to better and more secure livelihoods for target beneficiaries and their households.

Final consumers, in national and international markets, will also benefit indirectly from the proposed project as a result of efforts to preserve the quality and sustainability of Egyptian cotton and strengthen its competitiveness.

5 Stakeholders

The proposed project, in line with the UNIDO approach and mandate, will adopt a multi-stakeholder approach, building on the existing network and modalities of cooperation already established through the ongoing CSR initiative "*Cottonforlife*".

UNIDO promotes the active engagement of MALR and the Ministry of Trade and Industry (MTI) as main counterparts, as well as their affiliated institutions, in order to leverage their efforts to improve Egyptian cotton production and industrial transformation and improve their capacities to set up a regulatory environment conducive to an eco-friendly and socially responsible cotton industry. What follows is a description of the stakeholders involved.

- MALR and its affiliated specialized centres and institutes, namely The Agricultural Research Center (ARC). This was established in 1970 with the overarching goal of maximizing the economic return per unit of land and water.
- The Cotton Research Institute (CRI). By adopting a multi-disciplinary approach, the CRI seeks to enhance collaboration among cotton growers, agronomists and technologists for the development of new varieties of seeds that meet the needs of domestic and international spinners. CRI activities are conducted with the following long-term objectives: developing new cotton varieties to ensure increased productivity and tolerance to climatic events and pests whilst preserving the genetic purity of seeds; improving quality assessment techniques and developing agronomic practices to improve cotton yields and quality; identifying the most suitable agroclimatic zones for better spin ability; developing cotton classification and grading techniques and improving ginning techniques to better meet the needs of domestic and export markets.
- The Central Laboratory of Organic Agriculture (CLOA). It is mandated to promote organic agriculture practices in line with international standards, reduce the use of pesticides and other contaminating substances, monitor and issue certification for farms and organic products and conduct capacity building activities to increase awareness about organic agriculture techniques and practices.

The project seek the engagement of MTI-related institutions representative of the industry and specifically the textile industry. These include: the Egyptian Council for Textile Industries, the Industrial Modernization Center (IMC), the Federation of Egyptian Industries (FEI) and its Textile chamber, the Textile Export Council and Home Textile Export Council serving as forums for dialogue between national and international yarn and fabric importers and investors in the fields of spinning, weaving, dyeing and finishing with the final aim of strengthening the competitiveness of Egyptian exports in foreign markets. The project also seeks to engage the Textile Technology Center (TTC), the Egyptian Organization for Standardization and Quality control (EOS), the Productivity & Vocational Training Department (PVTD), the Fashion Design Center (FDC). FDC is a collaborative effort between MTI and the Italian Istituto di Moda Burgo (Milan) and is one of the most recently established centres in Egypt which offer students high quality education (both diploma and short-term courses) in the field of fashion and design in line with international standards. FDC also makes its facilities available (for a fee) for the nurturing of fashion entrepreneurs, and provides consultations and services (such as collection design) to Egyptian factories.

The Egyptian Cleaner Production Center (ENCPC) is also involved in activities related to the promotion of resource efficiency, cleaner production (RECP) and renewable energy, and the Productivity and Quality Enhancement Center (Kaizen) conducts activities related to the control and improvement of productivity and quality of manufacturing.

Similarly, by leveraging Filmar's network, synergies with Italian institutions representing the Italian textile and fashion industry (e.g. Italian Chambers for fashion and design, Italian Association of Textile machinery producers, Unionfiliere, Unioncamere and Italy's Chambers of Commerce) as well as Egyptian and international textile companies and brands, will be promoted to facilitate knowledge exchange and best practices in regard to quality and standardization, traceability, technological innovation, product design and marketing, among other things. The already-existing partnership with Alexbank will encourage start-ups by making funds more accessible.

Other key stakeholders include specialized technical associations such as the Cotton Arbitration and Testing General Organization (CATGO), the Alexandria Cotton Export Association (ALCOTEXA), the Cotton Egypt Association (CEA). CATGO is an independent national body that provides arbitration and technical services (moisture control, classing and grading services, etc.) for all operators in the textile value chain. CATGO pursues three main objectives: maintaining the purity of the Egyptian cotton varieties by preventing all forms of mixed varieties and/or grades; controlling and supervising all cotton handling processes starting from harvesting to local spinning and export, and preventing all forms of mixing and contamination; and (iii) giving concerned parties technical assistance with both seed and lint cotton production, and issuing recognized training certificates for classing cotton, fibre testing and moisture regain.

ALCOTEXA is a non-profit and non-trading organization of Egyptian exporters, including cotton trading and ginning companies. As a regulative authority, ALCOTEXA has the mandate to formulate export policies and set sales prices (indicative or minimum). Membership of ALCOTEXA is mandatory for all companies wishing to trade cotton in Egypt.

CEA, created by MTI and ALCOTEXA, is the sole representative of the registered trademark logo and licensing authority to certify the authenticity of the Egyptian cotton through DNA analysis, in an effort to ensure quality and prevent the marketing of non-authentic products.

The Ministry of Education will also be engaged as a collaborative partner for the project's activities targeting agricultural and industrial secondary schools and TVET centres. Similarly, synergies with national and international education and training institutions (e.g. University of Alexandria and the Don Bosco Institute of Alexandria, Italian and international academic institutes and renowned fashion and design centres) will be promoted with regards to curricula development and training of trainers.

6 Rationale

The potential for local processing of Egyptian cotton is still mainly untapped—the bulk of it is exported as a basic commodity. Some of the items produced have 70% imported component simply because raw material and other supply industries are not established.

The spinning of cotton yarn is the first stage in the industrial transformation of raw cotton into an intermediate textile product (yarn), and results in significant value addition.

Cotton yarn is an industrial commodity that is widely traded on the world market. Over 30 countries participate in the international trade of cotton yarn. Unlike finished textile articles, yarn is not influenced by changes in fashion and style because it is an intermediate product in the textile production chain.

The cotton yarn market is highly sensitive to shifts in demand for and supply of cotton at the international level. Hence, it is fortunate that yarn can be stored for long periods.

World trade in cotton yarn is estimated at eight billion US dollars, so the market is an attractive option for cotton-producing countries. The trade in cotton yarn offers a unique competitive opportunity with regard to China because China does not compete as much with other yarn producing countries as it does with countries that produce other fabrics and garments. In fact, China is the largest importer of cotton yarn in the world.

From a development perspective, promoting the spinning industry helps integrate the Egyptian economy into global value chains.

In order for Egypt to become a provider of middle- and upper-market textile products, supplying EU, US, Arab and African retailers and manufacturers with quick service and delivery of both finished products and intermediary textiles, and for the Egyptian textile industry to contribute to the growth of the national economy, create new employment and income generating opportunities, and increase its share in the global markets, the Vision 2025 strategy has established an action plan to achieve the following objectives:

- Create 1 million new job opportunities for skilled and semi-skilled workers;
- Train over 500,000 workers and managers as well as adding engineering diplomas for 100,000 technical managers;
- Increase exports to 10 billion USD using 70% of locally manufactured raw material;
- Make additional investments of over 13.5 billion USD in the industry.

In order to upgrade the Egyptian textile industry and integrate it into the global economy, the Vision 2025 identifies, inter alia, the following main strategic pillars, with focus on both finished products and primary textiles:

- Expand the industrial base through developing and enhancing the competitiveness of the local industry;
- Foster backward vertical integration, encouraging investments in primary textiles and fibre production;
- Foster export growth and market entry;
- Strengthen human capital development;
- Promote policy change and investment in infrastructure to unleash the growth potential of the industry.

Business models are changing, pushing the textile supply chains in new directions where the *sine qua non* condition is to establish cooperation and integration of actors along the whole value chain. The international markets and consumers are focused more and more on transparency and traceability requirements, underpinning the need to build sustainable supply chains starting from the very beginning: raw materials and fibre production. Hence, new business models need to be implemented through collaboration between farmers, spinners, weavers and big and small brands, to develop strategies and production models around sustainability, fairness and transparency of the textile value chain.

The decline in the production of Egyptian cotton, strictly related to the decrease in demand, and the ensuing decline of the Egyptian textile industry in terms of both production and exports, signal that the industry should implement more advanced and sustainable approaches to enable it to compete internationally and meet market and buyers' requirements, by attracting new private investment in order to equip itself with skilled labour and technologically advanced machinery and production lines. Therefore, the main aims of the project are: to expand local capacities so as to improve the productivity, competitiveness, inclusiveness and sustainability of the Egyptian cotton growers and processors; to establish business linkages and partnerships; to encourage innovation and human capital development; and ultimately, to better position the Egyptian cotton in domestic and export markets.

7 Comparative Advantage

The project benefits from and capitalizes on UNIDO's technical competence and experience in improving agro-industrial value chains in Egypt, as well as in modernizing the cotton-textile- garment (CTG) value chains—from the processing of raw materials to the production of textiles and ready-made apparel and improving market access, quality and certification infrastructures—in South Asia, Latin America, West and Central Africa (jointly with WTO) and the South Mediterranean region. Additionally, UNIDO's best practices in sustainable consumption and production (through RECP measures) in the South Mediterranean region and the promotion of renewable energy for industrial applications in Egypt will be leveraged.

In response to the challenges posed by sustainable development and in line with the 2030 agenda which promotes the multi-stakeholder approach as one which can significantly help to achieve the Sustainable Development Goals (SDGs), the project seeks to promote the inclusive and sustainable development of the textile industry and enhance the cotton's contribution to the Egyptian economy, employment and manufacturing value added and export growth by actively engaging the private sector (CSR, investors, partners, mentors, etc.), develop business partnerships, and leverage non-traditional funding.

In order to boost cotton production and its conversion into yarn, and to expand the cotton-based textile industry in Egypt, the project integrates two complementary strands of action: (i) improve the economic performance, inclusiveness and sustainability of cotton growers (particularly of LS and ELS cotton); and (2) improve the economic performance, inclusiveness and sustainability of private sector textile enterprises (processors of LS and ELS cotton, including SMEs and youth-led start-ups).

The proposed strategies are in line with UNIDO's approach to agri-value chain development, in as much as this development has a positive impact on employment, including in rural areas (off farm processing and income diversification), offers market access to smallholders, and creates business linkages to small and medium enterprises (SMEs). A value chain describes the entire range of activities undertaken to bring a product from the initial input-supply stage, through various phases of processing, to its final market destination, and includes its disposal after use. Accordingly, segments of the value chain to be targeted are prioritized based on their proven potential for local value addition (local content and processing), profitability, inclusiveness and sustainability.

As part of its efforts to build national capacities along the whole cotton value chain, the project intends to strengthen the capacities of the existing support institutions to set up a regulatory environment conducive to eco-friendly and socially responsible cotton production and industrial processing.

By developing and implementing the above strategies in close coordination with existing government and non-government support institutions, UNDIDO intends to:

- Benefit, directly and indirectly, at least 1,000 individuals depending on the cotton value chain
- Improve access to employment/entrepreneurial opportunities in the cotton value chain
- Support the increase of the productivity and competitiveness of cotton growers, ginneries and textile enterprises
- Promote the increase of export revenue
- Encourage investment in the cotton processing industries
- Promote the increase of cotton value added
- Promote more efficient use of resources in both cotton production and processing.

8 Cotton Sustainable Production

Based on lessons learned from similar ongoing initiatives implemented by Filmar in Egypt, and on international agricultural best practices, the project will raise the awareness of LS and ELS cotton growers by deploying pilot programs to demonstrate suitable options for improving cotton cultivation with regards to organic plantations, low contamination, and more efficient use of water, fertilizers and pesticides, and preservation of soil health. Technical sessions and on-the-job training will be complemented with study tours in order to increase growers' technical knowledge and their capacity to adopt sustainable agricultural practices, as well as their understanding of the market and buyers' requirements through direct contacts with the immediate consumers of their cotton, i.e. spinning mills.

Organic cotton, using natural rather than chemical inputs, pesticides and fertilisers, is environmentally sound, regenerates soil fertility, avoids contamination of land and water, and is healthier for farmers and rural communities themselves as it is based on organic inputs and fertilisers that are less likely to poison or contaminate users.

Unsustainable agricultural practices that rely heavily on agrochemicals will be discouraged. Cotton farmers rely heavily on agrochemicals such as herbicides to eradicate weeds, and on pesticides to control the numerous pests which, according to estimations, destroy around 15% of the world's cotton. The consequences of the uncontrolled use of agrochemicals include the deterioration of soil quality and productivity, contamination of groundwater, increasing resistance of pests, negative effects on biodiversity, and health risks for farmers.

Hence, it is essential that farmers be made fully aware of the consequences of not having adequate protective equipment and of utilizing hazardous chemicals. An integrated pest management approach and the use of pest control techniques other than pesticide application will be promoted in order to reduce reliance on pesticides.

The project will also encourage the adoption of efficient water management practices that help to optimize water use, maximise productivity, and minimise cotton's environmental impact. Moreover, better soil management practices, whereby nutrients are applied on the basis of the crop and soil needs, will be promoted as this improves and maintains the structure and fertility of the soil and minimizes erosion.

Furthermore, value addition activities, including processing and marketing of cotton seed by-products, are identified and promoted, thus contributing to increasing the income of cotton growers, thereby improving their livelihoods.

An increasing number of individual consumers as well as large companies, especially in niche markets, have become interested in certified organic cotton, in improving the quality of their supplies in line with international requirements, and in maintaining the social standards within the value chain. For all this, they are prepared to pay premium prices. Quality is, therefore, a prerequisite for trade and market access.

Any problems that arise during any stage of production or processing can cause irreversible damage to fibre quality and reduce the producer's profits as well as the those in other sectors of the textile industry including spinning, weaving, dyeing, and finishing. The efficiency of the gin is affected by the level of debris and contamination of the seed cotton. Therefore, the quality and value of yarn that can be spun is directly related to the quality of the lint cotton delivered to the spinning mill.

Practices for harvesting, managing and storing seed cotton so as to minimize debris, contamination and damage will be promoted. The knowledge and skills of target cotton growers will be upgraded with regards to quality standards, quality control and quality assurance systems, and laboratory testing procedures. This is essential in order for cotton production to better match buyers' quality requirements and international standards.

Ginners, classifiers, breeders and traders will be trained on the development, preservation, characterization of the quality and classification of the cotton fibre.

An integral part of the efforts to improve quality will be directed to strengthen the capacities of the MALR and its affiliated institutions to ensure that production conforms to quality requirements and international standards. An action plan and technical guidelines for the improvement of the quality of Egyptian organic cotton (standards for quality, growing, ginning and classification of cotton, and good trade practices for cotton) will be developed and disseminated.

Increasingly, buyers and consumers are demanding transparency and traceability. The project builds on the best traceability practices implemented by Filmar for the production of Nilo. Filmar is one of the certified companies in the framework of the Italian Traceability & Fashion scheme, managed by Unionfiliere and promoted by Unioncamere and Italy's Chambers of Commerce. It creates a voluntary certification scheme providing transparent information to consumers about: the locations of the main production stages in the production chain; the health values supporting the product; the product's 'environmental friendliness'; and the manufacturer's social responsibility.

Moreover, the cotton growing sector in Egypt suffers from a shortage of research on the breeding of new cotton varieties and increasing the yield per feddan. In addition to improving quality control and assurance, the capacities of the MALR and its affiliated institutions with regards to cotton-related agricultural monitoring is enhanced with a view to improving existing cotton varieties and developing new ones (via organic cultivation and low contamination, seed purification, development of new hybrids) based on market demand and related certification. Furthermore, the private sector will be encouraged to become involved in the experimental cotton plantation, in order to help reduce cotton stocks and meet the cotton trends and requirements of national and international markets.

In order to prevent the further deterioration of the quality of Egyptian cotton and to advance Egypt's position in the international market, improvements must be made to seed quality, cotton productivity, cotton quality and cleanness prior to raw fibre sales, and transparency and traceability. Cotton growers and relevant institutions must be proactive in the promotion and branding of non-contaminated and organic cotton in selected destination markets.

Finally, based on sustainable agricultural practices already being applied, the project, in close cooperation with the private sector, will develop/update training programs (including in-company practical training, internships, exchanges) targeting TVET students and trainers to ensure that such programs are aligned with labour market requirements.

9 Conclusion

The importance of moving up the value chain is illustrated by the percentage of the value added at each step of the CTG value chain, which increases with the level of processing. In line with the government priority of increasing the presence of private entrepreneurship in the textile industry, and unburdening the sector from the public spinners and weavers and their outdated technology and inefficient production, this project aims to identify and promote local value addition in terms of local content and processing, as well as related investment opportunities for downstream processing to ensure that Egyptian cotton yarn is processed domestically instead of being exported as lint cotton. In turn, this will also provide new and better employment and income opportunities to the local communities and hence better and more secure livelihoods.

This will be achieved through the provision of technical and business support services to LS and ELS cotton processors in order to improve their technical, technology, managerial and marketing capacities (supply chain management, production management, technology management, responsiveness to consumers' preferences nationally and internationally), as well as matching with investors and funding opportunities.

In addition to a sound analysis of the value chain, in order to compete better, all actors in the value chain need a better understanding of destination markets and consumers. Therefore, opportunities for the promotion of the LS and ELS Egyptian cotton in national, regional and international markets are identified through the established network of Filmar and its business linkages with high-end buyers in niche markets as well as through other networks of private sector companies. In addition, market familiarization missions to cotton-consuming countries will be organized to learn what their clients expect from them and to promote their products.

Given that quality, as previously mentioned, is a prerequisite for trade and market access, cotton processors' awareness and skills about the quality of processed cotton goods, process control techniques in spinning, weaving, dyeing and finishing, and the testing of processed cotton goods, will be improved.

Moreover, building on UNIDO's activities in Egypt and elsewhere aiming at promoting sustainable consumption and production patterns, the project also raises awareness of and gives support to target enterprises in the adoption of RECP measures for rationalizing the use and improving the re-use of water, energy, chemicals and other resources, starting with metering resource consumption, which will result in less adverse environmental impacts and will help the enterprises make savings on resources.

Special attention will be given to industrial wastewater treatment, as the textile industry, and specifically dyeing, consumes great volumes of water, and to the promotion of productive uses of textile waste through, for instance, innovative upcycling models.

The absence of skilled labour and national technical expertise constitutes another obstacle to the competitiveness of the Egyptian textile industry. The Egyptian textile industry needs to be supported by an efficient and updated education and training system, given that physical capital in the absence of human capital provided by efficient education and training is of less value. Therefore, one of the aims of this project is to provide the textile sector with skilled young entrepreneurs and managers as well as the necessary trained technical labour with a comprehensive set of competences and skills ranging from cotton cultivation to the production of yarns and fabrics as demanded by the industry. Filmar's and Alexbank's ongoing initiative to update training programs in industrial schools will be leveraged, and parallel efforts will be made to establish industry support services by upgrading technical and entrepreneurial skills for local advisory services to serve the textile industry and promote new and creative fashion design solutions (including but not limited to product design and marketing, garment modelling, innovative upcycling of textile waste, and export promotion).

The project will not only provide technical and business support services to individual enterprises, but will also support networks/clusters. In order for enterprises, especially SMEs, to be able to overcome sector-level constraints and increase their competitiveness, inter-firm cooperation within clusters is another important enabler of development and innovation. Clustering allows a concentration of resources and funding in targeted areas with high growth and development potential that can spread beyond the target locations (spill-over and multiplier effects). Clustering gives enterprises access to specialized suppliers and support services, experienced and skilled labour, and the knowledge sharing that occurs when people meet and talk about business. Clusters are particularly promising environments for SME development. Due to their small size, SMEs individually are often unable to realize economies of scale. Within clusters, SMEs can achieve shared gains through the organization of joint actions between cluster enterprises (e.g., joint bulk inputs purchase or joint advertising, or shared use of equipment) and between enterprises and their support institutions (e.g., provision of technical assistance by business associations or investments in infrastructure by the public sector).

Specifically, the project will facilitate joint market access and promotional activities, business partnerships with exporters and retailers, synergies with technical support institutions, fashion centres and academia to reinforce production, technological innovation, creativity and export capacities.

Building on UNIDO's accumulated expertise in developing and upgrading industrial zones and parks, the project will also identify, in close collaboration with national public and private stakeholders, the need for textile industrial zones/parks and develop related technical and financial feasibility studies.

In addition to upgrading and developing supply and production capacities, the project, in close collaboration with the MTI and its affiliated institutions, will promote the development of sectoral strategies and policies, which are necessary to improve the competitiveness of the cotton and textile industry. Special attention will be given to the identification of public-private partnership models not only in spinning and weaving, but also in the printing and dyeing sectors because of the large investment cost involved.

The awareness and technical and operational capacities of MTI and its affiliated institutions will be strengthened with regards to the services provided to the textile industry by the project to ensure competitive and sustainable cotton processing (technological innovation, quality control and assurance, RECP, innovative product design and marketing, and export promotion) and its conformity to market requirements and international standards.

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Waste Management Industry from Scratch Using Agile and Modern IT Technologies

Viacheslav Chernikov

Abstract Modern society has a significant impact on ecology, which is why recycling is mandatory for waste management. Existing recycling approaches have many issues and require decades and huge investments to be implemented. This chapter describes a strategy for building the waste management industry from scratch, based on recycling, Agile, DevOps, and modern technologies like cloud, blockchain, mobile, IoT, and AI. The research described below was backed by a group of scientists, entrepreneurs, and activists, and was hosted by the Repnoe School of Effective Communications (Voronezh, Russia). Since 2015, the team has done many different activities and research; it has educated students about recycling; implemented a supply chain for utilizing paper materials from school/college; made social adverts about battery utilization; made a map with recycling points; written guides on recycling at home or shops; analyzed international experience and research; system dynamics modeling; real-world simulation game modeling, business analysis and modeling; software modeling and architecture; and implemented a proof-of-concept. Full research results will be available in the upcoming book, Forming of Waste Management Industry in Modern Russia. Waste management involves many different player roles, and every character has its own goals, behavior patterns, and regulation rules. The first statement behind this study is: 'Waste recycling is more about economics than about ecology.' The final goal of recycling is to reduce the number of non-recycled materials in the overall waste. Businesses should process recyclable materials, and, therefore, the industry must be profitable. Two roles bring working capital—waste producers (payments for utilization) and recycled material buyers (sell goods with such materials on the market), so the government should first focus on the issues associated with these roles.

Keywords Waste management · Recycling · Cloud · Mobile · Blockchain · Agile · DevOps · Azure · Rapid software design

V. Chernikov (✉)
Research Project of Modernizing Waste Management Industry, Voronezh, Russia
e-mail: Slava.Chernikoff@Binwell.Com

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1 About Research

1.1 Introduction

During the last decade, ecology and waste management have become a hot topic in Russia. The number of issues and requests related to invalid waste management is significantly increasing, and the real percentage of recycled domestic waste is less than 5%. In comparing the situation in Russia with that in other developing and third world countries, we find them similar. Every study starts with a set of questions. Our initial questions are "What is wrong with waste management?" and "How can we fix it?"

In 2015, the author of this chapter headed this research project to find ways to modernize waste management in Voronezh City (an "average city" in Central Russia). The research team consisted of scientists, entrepreneurs, and social activists. The project's initial goal can be described as "find what is wrong with waste management and describe possible solutions." The research team analyzed the experience of using recycling in many developed and developing countries to detect common issues and best practices to adopt them for Russia.

As a final solution of the research, the author suggested a sophisticated software-hardware platform to grow the waste management industry with recycling using Agile, DevOps, cloud, mobile, IoT, AI, and Blockchain technologies. This chapter can be used by specialists working on modernizing and digitizing existing waste management systems as well as growing a waste management industry from scratch. Let us start our deep dive with project history.

Our study aimed to find ways of implementing recycling within current waste management processes in Russia. We used different tools and methods to build a holistic vision of the waste utilization process. This chapter describes a high-level view of the growing waste management industry with recycling based on modern technologies and user feedback. Digital transformation specialists who target the waste management industry can use the models and recommendations provided to upgrade current processes and systems. This study is based on multi-disciplined real-world experiments and research and aims to find a "quick way" of making waste utilization sustainable, structured, and profitable.

1.2 Brief Research History

2015. A group of 13 students from the Repnoe School of Effective Communications in Voronezh, Russia, started looking for models and approaches to reduce domestic waste pollution. The project started by analyzing the current state of waste management in Voronezh. More than 20 local experts, activists, regional government workers, and business players were interviewed. This helped the researchers to get an overview of the problem through the cause-effect system dynamics model. Rough recyclable materials estimations were also made. "Real-world" waste management business recycling processes were also explored by a group of Voronezh State University students during a simulation game called "Waste Market."

In addition to theoretical research, the team members also did some practical things like educating school/college/university students, collecting paper in school and college, posting social adverts in 200 multi-home apartments about the use of batteries, and more.

The main result of this research phase was understanding that no single local activity can change the situation, due to a lack of infrastructure and recyclable materials supply chains from 'kitchen to secondary usage.' That is why the team focused on the business process to find profitable and sustainable supply chains.

At the end of the year, research results were introduced at the Civic Chamber of the Russian Federation.

2016–2017. The project team prepared an intermediate report to summarize the first research phase results. This report was sent to the Administration of the Voronezh region, but no response followed. The team focused on making requirements for a sophisticated pilot to validate assumptions and gather real data and feedback from citizens and business players.

2018–2019. Cloud platform architecture was introduced as a solution for a unified, scalable, sustainable, and profitable recyclable waste supply chain from the kitchen to secondary usage. To speed up real-world integration and growth, the suggested platform should also educate and motivate all participants. The next sections will cover the cloud platform in detail. Proof-of-concept versions of mobile, cloud and web applications were developed.

1.3 Research Results

During the research phase of 2015–2018, the following scientific results were formalized:

1. A logistics model by the National Research University of Electronic Technology optimized vehicle routes based on real-time events on container occupancy. Software implementation of this logistics model can be used as a cloud service.
2. The cause-effect system dynamics model (by participation-modeling experts Elena Bakhanova and Anna Gladkih) can be used to control the risks and side effects of increasing recyclable materials in supply chains and upgrading the waste utilization process regionally or nationally. As a result, the team got the list of relationships with positive/negative/neutral connections between different aspects of the waste utilization process and its related activities.
3. The simulation game Waste Market (by Dmitry Kavtaradze) was designed to understand real people's behavior in the current (hard recycling with no feedback) and upgraded (easy recycling with feedback) waste utilization processes. As a result, the team built a simulation game model. It told players about the ability

to speed up recyclable materials supply chain growth by providing feedback for citizens (rewards for recyclable waste and proof that 'my waste was recycled') and business workers (increasing high-quality recyclable materials, rewards/penalties for playing fairly/unfairly).

4. Business process models and cloud architecture (by Viacheslav Chernikov) control the waste management industry in the digital age, including apps for citizens, business workers, and government services. This cloud platform should be implemented using lean and agile approaches based on real-world feedback and metrics and by providing maximum value for end-users. The usage of real data on a national level will allow the calculation of the actual number of secondary waste in all existing supply chains. The government should focus on increasing that number while keeping it accessible and profitable.

Based on research results, we formalized the following principles on making the waste management industry in the digital age:

- Accessible: people should be able to recycle without any personal limitations in public places and houses.
- User-Friendly: it should be easy to learn the principles of waste sorting and utilization infrastructure.
- Profitable: all supply chains should bring money to businesses to make the industry attractive for investment.
- Open: high-level data and statistics should be accessible for third party services, citizens, and partners.
- Sustainable: using recyclable materials should not be affected by an international or territorial economics situation.
- Manageable: all business process steps should be controlled by gathering real data, providing reports, and handling semi-automatic issues.
- Unified/Scalable: business processes, tools, and rules should be equal for all territories and also compatible with international agreements.
- Centralized: To find the overall 'X value' (proportion of recycled/not recycled waste), all data and planning should be done by one service. Centralization will allow the government to control the industry and increase the X.

The Cloud Platform should be created with these principles in mind.

2 Improving Business Process

To upgrade the Waste Management Industry (or create it from scratch), it is necessary to start with money-waste transactions and formalizing the business process. This chapter includes a description of the business process and brief actors' behavior.

2.1 Blackbox Model

To simplify the model of the Waste Management Industry, it is enough to focus on economic aspects and the recyclable material supply chain. The high-level blackbox model is shown in Fig. 1.

The base value to control for high-level, industry management should be ‘the X value’ (T—total waste weight equal to $Y + Z$, Y—recycled waste weight, Z—waste delivered to storehouse):

$$X = Y/(Y + Z)$$

In general, non-recycled waste can be passed through an incinerator, but this process will produce some new waste for utilization and costs a lot. This paper is focused on increasing Y value, but in general, it is possible to reduce the overall T value of produced waste to achieve a ‘zero waste’ model. The ideal ‘zero waste’ scenario will have some ways of reusing organic waste and high-cost recyclable materials and will require extra efforts from citizens and government (subsidize non-profitable waste utilization). It is costly to achieve 100% real recycling. For example, very distant territories may consume and produce plastic and it is hard to utilize it the proper way. As a first goal, it is enough to achieve 80% of recycling before investing money or citizen awareness into high-cost business processes.

Keeping a focus on the waste-money supply chain model allowed the team to formalize the process using Business Analysis (International Institute of Business Analysis 2015). The final scheme of the formalized business process is shown in Fig. 2. Current work focused on terms and business roles stated in Russian waste utilization regulatory rules and market terms.

This business process model was used by Dmitry Kavtaradze (scientific advisor of the research project) to create a simulation game that split into two parts: recycling and without recycling. The game was played with 30 university students and showed that citizens are ready for waste sorting if they get feedback from the system. This feedback can be provided as a payback (preferable) for recyclable waste or as ‘trust

Fig. 1 Blackbox model of waste utilization business process with recycling, prepared by Viacheslav Chernikov

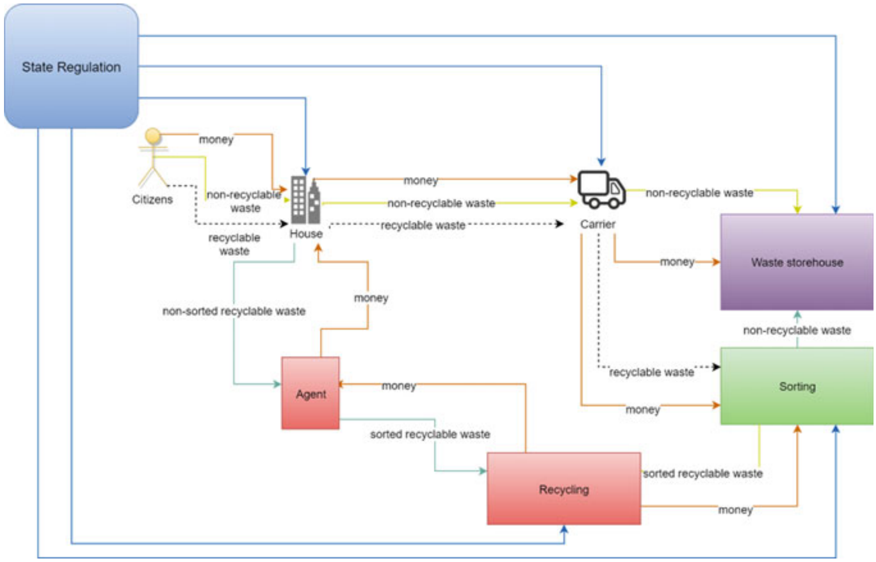

Fig. 2 High-level waste utilization process with recycling by agents. This is based on modifications for the simulation game Waste Market by Dmitry Kavtaradze, initially prepared by Viacheslav Chernikov

signs' (e.g., information that 'my waste was recycled'). Business process schemes without any feedback demotivated players, and they stopped sorting within a short period.

To find a way of improving the Waste Management Industry with the sustainable recycling process, the project team described all business roles involved in waste management:

- State regulators
- Carriers
- Waste producers (citizens and organizations)
- Household management company
- Sorting business
- Recycling business
- Landfill management companies

To describe all these roles within a complex business process of waste utilization, the following behavior aspects were analyzed (but not limited to):

- High-level goals
- Communication tools to deal with the waste utilization process

This chapter does not include behavior algorithms and regulatory rules (specific for Russian Federation) for different roles, but these data will be used to implement a cloud platform for the waste management industry.

2.2 Business Process Roles (Actors/Players)

All noticeable business process actors described below apply complex systems, reaching a maximum set of goals from different players.

State regulator: Current work describes all government and state services as a single actor, or state regulator, within the waste utilization business process.

State regulator goals:

- Control and manage business players to support the sustainable waste utilization process
- Stimulate business players based on real economic aspects
- Get taxes and ecological payments
- Reduce the negative ecology effect of waste utilization
- Reduce the number of complaints from citizens
- Implement the whole business process and regulate it officially

State regulator communication tools meant to deal with waste utilization: legislation, licensing, monitoring, and getting feedback/complaints.

Citizens, Small, and medium waste business producers (offices and other public places). These players are first who bring money (for waste utilization) to the business process.

This player has the following goals:

- Reduce payments for waste utilization
- Get an increased infrastructure and service quality (container cleanness, location, enough count, modern design)

Communication tools to deal with waste utilization:

- Agreement with the household management company (HMC) about the waste utilization service
- Complaints to HMC
- Complaints to state regulators
- Public protests if the state regulator ignores massive complaints

The household management company (HMC). These companies take money from citizens/businesses to support household infrastructure, including waste utilization.

HMC's goals:

- Reduce risks by state regulator checks, followed by an increased number of complaints
- Reduce waste utilization costs

HMCs communication tools to deal with waste utilization:

- Agreement with a waste transportation company (or regional operator)
- Agreement with citizens
- Transfer payments for waste utilization based on agreements
- Implement waste segregation to sell recyclable materials

A waste transportation company. Picks up the waste and transfers it to the sorting company or landfill. It can work with a fixed, floating, or semi-realtime schedule.

Player primary goal: increase profit and overall volume of transport service (rated by money/car hour).

Communication tools to deal with waste utilization:

- Agreements with HMCs, regional operators, and other businesses for waste transportation
- Agreements with landfills
- Optimization of inner business processes
- Licensing by state regulator
- Lobbying and unfair market competition

Recyclable waste resellers are agents who buy recyclable waste from citizens and other waste producers, then sort and sell it for recycling or more extensive resellers. The most valuable and widely used recyclable materials are cellulose, glass, plastic and metals. These types of recyclable materials do not require licensing to be processed by a business company.

Player business goal: increase profit and overall volume of resold recyclable materials.

Agent communication tools to deal with waste utilization:

- Implement infrastructure for recyclable materials processing
- Search for recyclable material sellers (personal or business)

Recycling factories. This is the second player that brings money to the waste management industry (the first one is a waste producer).

Player business goal: increase profit by increasing quality and overall volume of sold recycled materials and by decreasing costs of recycling.

Communication tools to deal with waste utilization:

- Agreements with waste sellers and resellers
- Agreements with buyers

Sorting company. Make sorting of rough materials at any scale and any material type.

Player business goal: increase profit by increasing quality and overall volume of sold recycled materials and by decreasing costs of sorting.

Communication tools to deal with waste utilization:

- Agreements with waste sellers
- Improve sorting with automation
- Load balance agreements with other sorting companies

Landfill management company. These companies are interested in getting as much non-recycled waste as possible using fair and unfair techniques. On the other hand, these companies know the market and can invest in an upgrade to find a profitable place within massive recycling supply chains.

Player goals:

- Increase profit by increasing the overall volume of buried waste
- Maximize the lifetime of landfills

Communication tools to deal with waste utilization:

- Agreement with a transportation company and regional operators
- Unfair play:
  - market monopolization
  - utilization rates manipulation
  - unaccounted waste utilization

Regional operator. This role was introduced in Russia in 2019 with the intent that the regional operator would manage and control the waste utilization process rather than the state regulator. A regional operator is generally a kind of local management company for a specific territory that can be connected to a Cloud platform like local Uber management companies.

3 Waste Management Industry Maturity Levels

Even in developing countries, modern society produces many kinds of waste. Every type requires a dedicated supply chain to utilize waste or recyclable materials. This work focuses on domestic waste.

Implementing domestic waste utilization requires a profitable business process in addition to the existing infrastructure. The necessary infrastructure includes:

- waste bins at the household level
- containers for waste collection from multiple households
- vehicles to transport waste
- landfills as a final destination point for garbage

Optional infrastructure includes recycling infrastructure:

- points/services that buy recyclable waste/commodities
- sorting services
- incinerator services
- businesses that produce raw materials from recyclable waste

Depending on economic aspects of the waste utilization process, such as implementing and supporting infrastructure and making businesses profitable; cultural aspects, such as citizens following the desired behavior patterns; and ecological aspects, such as reducing the impact of waste utilization and mining of raw resources, it is necessary to find a reasonable balance.

For a better understanding of waste utilization processes and specific issues, it is necessary to classify waste management industries with maturity levels based on X

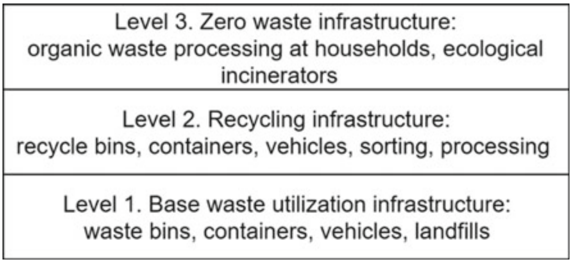

Fig. 3 Waste management industry maturity levels, prepared by Viacheslav Chernikov

value, which is the percentage of recycling. With this classification, it is possible to analyze and compare waste utilization in different territories.

Currently, different territories are at different levels, from no recycling to zero waste (Fig. 3):

Level 1. No recycling (X <= 5%). This level is a basement for the recycling process. First of all, any territory should implement waste utilization with one bin where all types of waste go to one place. Only the strictly necessary infrastructure is required, and the business process can be backed by payments from waste producers (people/businesses pay for waste utilization). Most developing and third-world countries are on that level, and they have many issues, even with essential business processes that should be fixed before implementing recycling.

Level 2. Partial recycling (5% < X <= 60%). As a next step of upgrading waste utilization, most developed countries implemented some ways of recycling. The X value may vary from 10 to 50%, depending on the territory. Waste sorting and optional infrastructure are required for that level. Every person should sort at private/public places to detach the recyclable waste. Different waste classifications exist in different territories, but roughly the sorted recyclable waste has to be precisely sorted before final processing everywhere. Numerous bin and container types make it hard to place, support, and maintain infrastructure. This, in turn, increases business process costs mentally (more time for education and searching for bins/containers for specific waste types) and financially (more containers, vehicles, and actions to utilize). This work suggests using a 2-bins sorting model (recyclable and non-recyclable), which has already been successfully implemented in many territories. On that level, the government should focus on increasing the X value to 50%. Level 2 can be implemented only with correctly working Level 1 processes that handle more than 80% of produced waste and have no protests from citizens and business players.

Level 3. Zero Waste (X > 60%). Most domestic waste is organic by nature and will destroy itself quickly without a negative ecological impact, so it is possible to talk about zero waste mode after reaching an X with 60%. To increase the X value, it is necessary to make extra investments (both financially and mentally). On that level, organic waste should also be recycled to produce manure, bio-gas, or fuel. As a part of the extra utilization step, it is also possible to use high-cost incinerating that meets rigorous ecological requirements. The zero waste mode can only be implemented on top of profitable and sustainable Level 2 recyclable processes.

To select an exact number of bins, it is considered best to use two-bin sorting (recyclable and non-recyclable) as the most straightforward way from mental (education curve), practical (less space and bins), and integrative (easy to install) points of view. These two-bin containers should always be placed together: one with a sign (sticker or stencil for painting) and one regular without any specially added signs. Containers for recyclable waste should be equipped with a cover and the recycle symbol.

4 Fixing Business Process Issues

To make recyclable material supply chains sustainable, profitable, and scalable, it one must specify the most common problems faced by different business process actors as they are defined at various levels. The term "issue" in the current context is used to determine external (infrastructure/environment) or internal (lack of knowledge or intent) barriers that prevent a single person or organization from implementing correct behavior within the required business process. The following tables present a list of the most frequent issues faced during public talks and while interviewing experts and regular citizens (Tables 1, 2 and 3).

All business players making money from recyclable materials (sorting, reselling, reusing) are bound by the global market of recyclable waste, which can be unprofitable in badly structured markets because of its lack of infrastructure and wrong social behaviors as well as the many issues listed above. The government should

Table 1 Issues faced by waste producers (households and organizations), prepared by Viacheslav Chernikov

Level	Issue type	Issue
1	Infrastructure	No functioning waste bins within 5-min walking distance
	Infrastructure	No functioning and free containers within 15-min walking distance
2	Infrastructure	No bins for recyclable materials
	Infrastructure	No containers for recyclable materials
	Motivation	No feedback (with information or money) on successful recycling
3	Infrastructure	High costs of recycling organics on the household level
	Education	Long education curve for household/organization members
	Motivation	Lack of personal motivation to make extra efforts

Table 2 Issues faced by household management and waste transportation companies, prepared by Viacheslav Chernikov

Level	Issue type	Issue
1–3	Infrastructure	Containers are broken
	Infrastructure	Wrong transportation: incorrect vehicle type for the specific waste type or incorrect schedule

Table 3 Issues faced by sorting and reseller (agents) companies, prepared by Viacheslav Chernikov

Level	Issue type	Issue
1	Market	Not enough recyclable materials to be profitable
	Education/Motivation	Poor quality of available recyclable materials
2–3	Education/Motivation	Large % of non-recyclable or hardly recyclable materials inside recycling waste bins
	Market	No access to recyclable material supply chains

take control of markets to make them profitable for recycling businesses at any scale, independent from the global situation.

In general, the state regulator should control all issue resolutions and retrieve as much real data as possible.

There are also some high-level business process issues:

- No simple way to send complaints/feedback and control resolution (communication)
- Hard to find a reliable business partner (communication)
- High costs for transportation and sorting due to poor optimization (market)
- Recycled materials price is higher than equal raw materials price (market)
- Limited market for recycled materials (market)
- No way to balance sorting, transportation, and recycling supply chains between different companies (market)

To fix most of these issues, it is necessary to use a single IT platform that will gather feedback, complaints, and data from businesses and provide optimization, education, motivation, and communication tools.

5 Cloud Platform Architecture and Implementation

Cloud platform architecture, like any other software, should reflect the real world by modeling a complex domain model. The waste management domain model should also reflect different aspects of complex waste utilization and recycling processes, and include tools to motivate and educate people.

5.1 Domain Model

To find a way to make a solution for managing the whole process from citizens to products with recycled materials, other approaches were analyzed including (Kumar et al. 2017; Poon 1997; Aazam et al. 2016; Sharmin and Al-Amin 2016). The approach described in this paper is focused on making a complex chain from the kitchen (citizens' habits) to final products with recyclable materials. The current vision of software-hardware complex is:

- cloud platform to handle and store all the data, analyze requests and complaints about artificial intelligence, process all transactions and requests/complaints with blockchain, process user activities, provide a backend for user information, analyze collected data to find ways of increasing the overall level of recycled waste
- mobile and web apps for citizens with information, motivation and getting feedbacks/requests/complaints
- mobile and web apps for state workers to handle requests/complaints/accidents and get reports to critical KPIs and information for business players
- mobile, web, and IoT apps for business players to collect tracks of vehicles, key numbers, and transactions, track planning, information about other business players, and interface to communicate with state services and citizens

The main goal of developing a unified cloud platform is the integration of all market players in the waste recycling process across any region or country. Critical areas for which the cloud platform will be created:

- organization, regulation, and optimization of solid-waste recycling business processes across a region or country
- involve citizens and businesses in the process of recycling solid waste
- provide direct communication channels for all market players with rating-based feedbacks

The diagram in Fig. 4 shows the cloud platform's key functional blocks, which are divided into the following domains:

- business process (help businesses to do the job effectively)

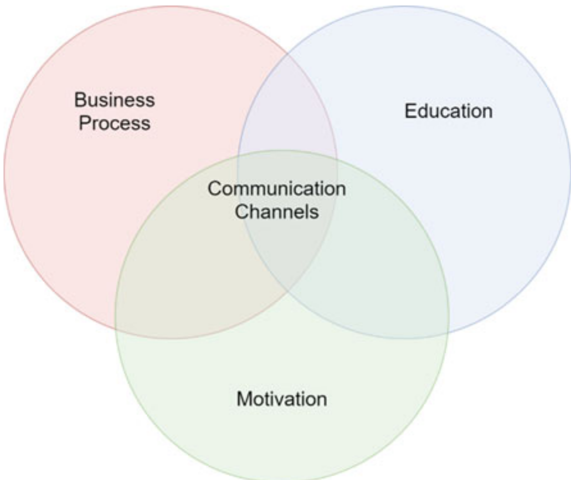

Fig. 4 The domain model of the cloud platform, prepared by Viacheslav Chernikov

- education (provide educational materials for citizens, businesses, and state regulators)
- motivation (provide ratings, feedback, statuses, financial support for market players, citizens, and state services)

Integrating all these blocks into a reliable system requires communication channels. There are two main types of such communication:

1. Messages with requests, complaints, feedback, or ratings by all business process players, including tracking statuses and contract completion, should be based on smart-contracts technology. These messages should be pre-processed with artificial intelligence services to reduce the level of fake, incomplete, and junk messages. Additionally, AI-based text classification will allow automatic responses with possible answers to be provided.
2. Transactions of money and waste between all business process players (citizens, businesses, and the state) based on blockchain technology.

The fundamental concept of the cloud platform is to provide end-users with the most valuable features. That is why Agile (Rothman 2016) and Lean (Ries 2011) approaches should be used together with DevOps practices.

5.2 High-Level Architecture

The cloud platform should consist of many components. Figure 5 shows the high-level solution architecture.

The cloud platform is a set of services for providing different application interfaces (API), collecting and storing data, monitoring critical values, and implementing different communication channels. A collection of user applications (interfaces) should be developed for the following stakeholders:

- citizens: mobile and web applications for learning materials and to provide feedback, including a rating system
- state services: mobile and web application for getting statistics and educating all players; API services for integration with other online services
- business players: mobile application for on-site workers, a web application for back-office tasks, IoT devices for tracking critical values, API services for integrating with on-premises systems
- partners: providing API services for retrieving statistics

The Rapid Software Design approach introduced in (Chernikov 2018a, b; Chernikov et al. 2018) can be used to simplify and speed up the development of mobile and web applications.

Technologies and services that are required to implement cloud and client (web/mobile) applications include but are not limited to:

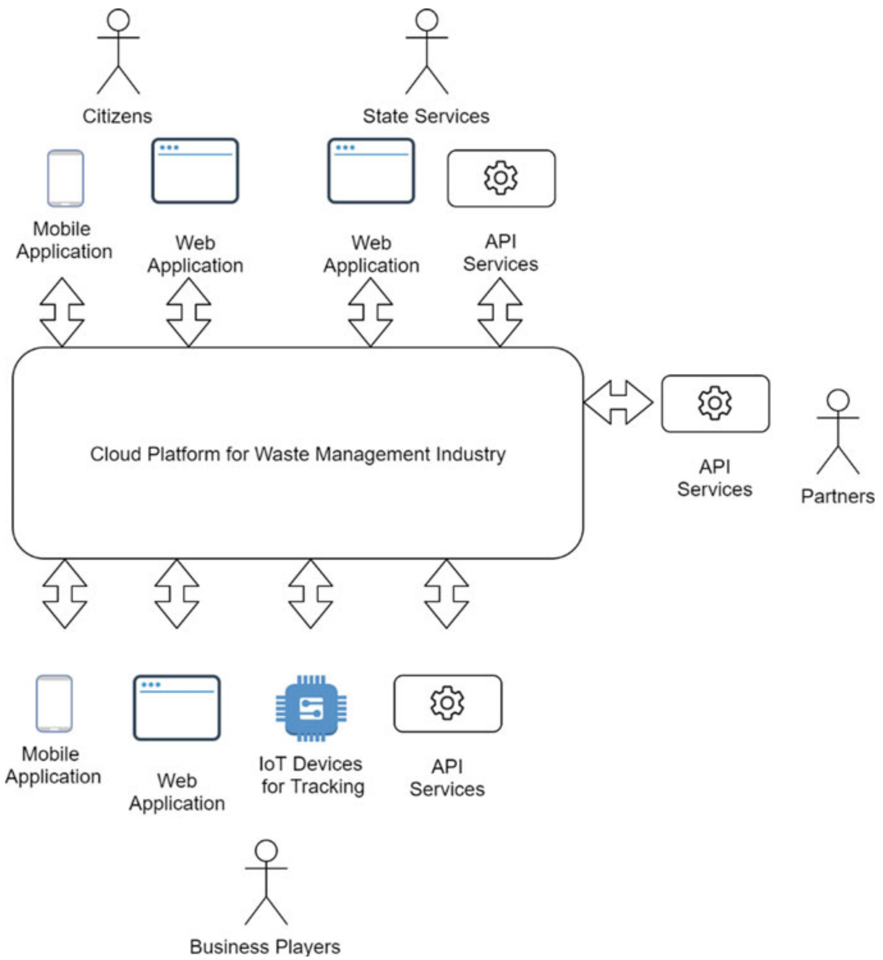

Fig. 5 High-level architecture of the cloud platform for the waste management industry, prepared by Viacheslav Chernikov

- Languages and frameworks: C# (.Net Core, ASP.Net Core, Xamarin.Forms for iOS/Android) and JavaScript (React.js, Node.js)
- Cloud backend: Azure App Services, ASP.Net Core, Azure Functions
- Databases: Azure Cosmos DB, Azure SQL, Azure Blockchain Service
- Storage for unstructured data and files: Azure Storage
- Messaging: Azure Notification Hub, Azure Service Bus
- AI: Azure Cognitive Services (Vision, Search, Decision, Text Analytics), Azure Machine Learning
- IoT: Azure IoT Hub
- Security and User Management: Azure Active Directory, Azure Security Center
- Analytics and Monitoring: Azure Application Insights, Microsoft PowerBI

- DevOps: Azure DevOps, Visual Studio App Center, Azure Dev/Test Lab

Using only two main languages (C# and JavaScript) will allow us to simplify and standardize the development process with a unified number of tools and practices.

To solve business process issues, some modern technologies should be used:

1. Artificial intelligence:
   - Images classification from mobile apps while sending automatic requests for users on the client-side
   - Text requests/feedback classification from mobile and web apps and sending an automatic response for users
2. Internet of things:
   - Vehicle-tracking with smart contracts for automatic detection of issues on the client's side
   - Connected weighing devices with smart contracts support to track the weight of recyclable materials
3. Blockchain:
   - Money-waste transaction tracking should be done in internal currency. In general, the exchange rate can be fixed with 1 INT_CUR = 1 CNTR_CUR, where INT_CUR is internal platform cryptocurrency, CNTR_CUR is a country currency. All loses on currency exchange should be covered by platform fees, percentage from every transaction, and the exact number should be defined for real integration. Also, active citizens can use internal currency as reward points and spent it in internal online shops (sell goods from recycled materials).
   - Tracking complaints/feedback allows state services to get currently issued tickets and automatically find the organization that is responsible for resolving specific issue.

The cloud platform should just be considered as a tool for helping the modern waste management industry with recycling as society moves towards zero-waste status. Contemporary management approaches like Lean and Agile should be used to control and grow the industry. Also, DevOps tools and practices will help to speed up cloud platform development as fast as the real industry will need. User feedback should support platform evolution.

6 Industry Growing with Lean/Agile/DevOps Approaches

To build the waste management industry with the cloud platform in mind, it should be strongly considered that the cloud platform operator (business company) should be profitable and make money on transaction fees. The government should regulate the industry's rules, investments, and cloud platform economics.

To get the first partners and begin to earn first money, it is possible to start with existing low-profit markets. Using IT and social marketing offline will help to structure such niches.

There are some potentially profitable businesses, especially with government support and social marketing:

1. Recyclable waste reselling: Buy sorted recyclable materials from citizens and companies, possibly grow with office buildings and public places, implement two-bin sorting and send waste pickup requests via smartphone when a container is full.
2. Reusable commodity reselling: Buy old furniture, clothes, TVs, fridges, smartphones, and other used goods for low prices and recycle them. Growth is possible by providing selling (your commodities = money for you) or paid (you pay for utilization) waste removal requests.

Due to the high costs of utilizing toxic waste like batteries, it is necessary to stimulate business reselling with different regulation rules (e.g., equip every grocery store with bins for batteries and recyclable materials).

Further improvements to the business process could include logistics optimization with automated vehicle trip planning, decreasing sorting costs with automatic lines, and increasing recyclable materials quality by educating and motivating citizens.

To improve apps and services (online/offline), it is necessary to get feedback and data from real users, including requests, complaints, suggestions, comments, ratings, application usage metrics, and technical and anonymized data.

The cloud platform can be developed step by step, by using a DevOps approach and tools to speed industry growth.

7 Education and Motivation to Speed Industry Growth

Waste recycling became popular within the last 50 years, and it took decades for most countries to integrate waste sorting at the household level. Based on results from European countries and the US, this work suggests using mobile/web apps to educate and motivate citizens to do the sorting at home. Previously, the use of a two-bin (recyclable/non-recyclable) sorting model was recommended to reduce mental complexity and mess within containers, improve accessibility, and make waste sorting user-friendly.

The most active target audience is potentially be young mothers because they care about their children's future, the environment, and cleanliness and have enough free time to learn how to sort waste.

On the other hand, many residents in large modern cities (500,000+ population) already know about waste sorting and recycling from watching TV, using the Internet, or traveling abroad. This should be considered when making educational resources available—most of them should focus on children aged three to nine and elders above 60 who are not familiar with waste sorting.

The cheapest and straightforward way to educate children and elders about the correct way to sort waste is by using smartphone games. Such digital games could have the following features:

- the full game course should include 21 days of regular training with automatic reminders to make a sustainable habit
- the game should consist of several mini-games and have different levels
- the game can also include international methods of waste sorting for those who travel abroad
- a player should be rewarded with points and achievements while learning waste sorting
- the game should also provide ecological advises and interesting facts (e.g., ‘one battery can poison one cubic meter of soil’).

To simplify the integration of recycling, it is necessary to print stickers with and international ‘Recyclable’ sign: A5 sized stickers for bins and small stickers to place on recyclable goods. These stickers can be sent automatically to users registered on the cloud platform.

Complete education materials should also include different static content (video, text, presentation) for citizens, activists, state services, and business workers so they can use waste sorting and the cloud platform properly.

Other education topics should rely on real-world practical advice and provide simple ready to use vMeme (Beck and Cowan 2005) phrases about recycling with the following questions:

- What kind of waste is recyclable?
- How to make recycling at home?
- How to join the cloud platform?
- How to get rewards?

There should be a set of simple meme phrases for educational materials and advertising.

To make waste sorting (new citizen behavior!) integration successful and fast, it is strictly necessary to provide communication channels between supply chain actors. Structured communication should include the following message types:

- Issue complaints about business process violation, e.g., a container is broken, or a vehicle delivered recyclable waste to landfill instead of sorting line
- Feedback on business players’ work quality based on comments and ranking
- Activist meetups and announcements

Such message senders should get reward points based on smart contracts and activity completion results. These reward points can be equal to or replaced by internal cryptocurrency to simplify their usage and adoption. Also, citizens can reach different levels of platform membership and get a special universal loyalty card with a discount for retail stores (a higher level will lead to more significant discounts).

Motivation is mandatory for making the industry’s growth sustainable so that all positive actions should be motivated. Another motivation tool is providing open data for different territories and households—X value at different scale and structured as a leaderboard.

Using points, achievements/badges, levels, activities, open leaderboards, and real rewards will require some gamification algorithms to be implemented within the cloud platform. In the early stage of cloud tools integration in the real world, it is recommended to implement offline contests and activities (e.g., one-day training of waste sorting at a specific territory) with free stickers, toys, and other prizes.

On the other hand, it is necessary to stimulate fair play with clear rules. Companies with wicked ranks should be blocked at the platform, and all issues (especially unfixed) should lead to penalties (e.g., a person who sent an approved issue will get some cryptocurrency from the company that responded to that issue).

Using communication channels, motivation, and gamification will increase people's involvement and speed up the growing waste management industry to Levels 2 and 3.

8 Results

As mentioned previously, the current research project was started in 2015 with the questions, 'What is wrong with waste management?' and 'How can we fix it?' To summarize the answer, it is possible to state that the 'key of most issues is lack of or invalid communication between business process actors.' Communication means all types of information exchange between business process actors such as money transactions, actions within the business process, real-world data, texts, photos, video. To structure these information channels, it is necessary to implement a cloud platform that should be backed and controlled by the government as a stable industry. So, our research came to this answer, 'Communication within the business process is outdated and should be upgraded with modern technologies to scale recycling.'

Current project scientific results include the following models:

1. Logistics model by the National Research University of Electronic Technology
2. Cause-effect system dynamics model by participation modeling experts Elena Bakhanova and Anna Gladkih
3. Simulation game model by Dmitry Kavtaradze
4. Business process models and cloud platform architecture by Viacheslav Chernikov

Current project state:

- scientific research finished and described in this paper
- proof-of-concept implementation with prototypes of mobile and web applications, cloud backend, Agile, DevOps, C#/.Net, Azure
- implementation of landing page http://яразделяю.рф (http://xn–80aidgwz7hbg.xn–p1ai), stickers, marketing materials

- a base assumption about the profitability of a cloud platform on a large scale validated by business experts—IT-backed business to handle supply chain of recyclable materials 'from office to reselling' can process orders and transactions like Uber
- sharing scientific results in several articles and public talks/presentations
- searching for markets with a possible 'Shut up and take my money!' situation (a phrase from cartoon series, *Futurama*, about a fascinating and attractive product) and starting a pilot to handle recyclable material supply chains 'from office to reselling,' to get real economics numbers and profitability on a small scale for extrapolation.

9 Discussion

Current work describes how to upgrade waste management with modern technologies and provide unified 'Uber-style' applications for different types of users and businesses involved in the waste management industry. Significantly, this work is focused on implementing structured communication channels between different user roles rather than making 'smart recyclable bins' and 'continuing to monitor" solutions.

This paper also introduced the maturity levels of waste management based on 'X value' and existing infrastructure. This work strongly suggests two-bin sorting on behalf of education and motivation scenarios in order to speed up the movement toward zero-waste.

Known limitations of that work include the necessity of validation for education and motivation aspects to find the ready-to-use solutions. Also, it is necessary to mention that most business players within the waste management industry, especially in developing and third-world territories, have deficient management and IT maturity levels that can slow down industry growth. That is why future research should be focused on obtaining real numbers and feedback by real users so as to confirm the assumptions related to the education and motivation of users.

10 Conclusion

This article contains a high-level vision of the cloud platform that should be used for modernizing the waste management industry or implementing it from scratch. In order to develop a sustainable business process of waste management, it is necessary to add education and motivation domains to the cloud platform and implement the whole system parallel to offline activities.

The cloud platform should provide dedicated user interfaces for different types of users and focus on key X-values—the ratio between the recycled/not recycled solid waste.

This paper describes the set of approaches that can be combined to build sustainable and scalable recycling processes on the way to zero waste and low ecology footprint with the current form of consumption.

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Green Information Technology

A Bibliometric Analysis-Based Review on Green IT

S. Zaung Nau and Dora Marinova

Abstract With the increasing global greenhouse gas emission (GHGE) from ICT usage, several research projects have been conducted in the areas for Green IT development (such as optimal resource allocation algorithms, deterministic heuristics approaches) and Green IT deployment (integrated framework approach). Although there was significant progress in Green IT research during the period of 2008–2013, it has declined gradually in recent years. The findings from all of these Green IT research play a vital role in improving the resource optimisation, which can result in GHGE from ICT usage. This book chapter presents the findings from bibliometric analysis, co-authorship and citation network analysis on Green IT articles. The findings show that the numbers of total related articles increased from 2008 to 2013 and gradually decreased in recent years. USA, Germany, India, Australia and England are the leading countries. The high average citations of articles from Australian scholars reflect their significant academic value in this Green IT research area, although the funding support from Australia research council on Green IT is comparatively low. There is a need to encourage more academic collaborations with co-authorship to share experiences, knowledge and skills for more innovative solutions. The citations among articles from worldwide are widely distributed and well linked among articles from various countries and academic institutions.

Keywords Bibliometric analysis · Green IT · Co-authorship network analysis · Citation network analysis

S. Zaung Nau (✉)
School of Management, Curtin University, Perth, Australia
e-mail: Z.Nau@curtin.edu.au

D. Marinova
School of Design and the Built Environment, Curtin University, Perth, Australia
e-mail: D.Marinova@curtin.edu.au

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1 Introduction

Climate change has been adverse in recent decades, and environmental sustainability is the serious challenge that we need to address urgently. It is essential to reduce the global greenhouse gas emission (GHGE) as discussed in the Paris agreement. Nevertheless, there has been little attention to ICT as a significant contributor to total global greenhouse gas emission. Belkhir and Elmeligi (2018) estimated that GHGE from ICT usage would be increased from 1.2% (min estimate) in 2007 to 3% (min estimate) in 2020 of a total global footprint. It was estimated that GHGE from ICT usage has accounted for nearly 1,700 metric tons of carbon dioxide equivalent (Mt-CO_2-eq) (min estimate) and 2,000 Mt-CO_2-eq (max estimate). They also projected that GHGE from ICT usage would reach to 14% of the total global footprint in 2040.

With fast-growing GHGE rate from ICT usage, it is vital to understand which ICT categories will be contributing more to GHGE than others so that Green IT research will be able to focus more to tackle these issues. Belkhir and Elmeligi (2018) projected that there would be a dramatic increase in GHGE contribution from smartphone usage from 4% in 2010 to 11% in 2020. Another rising share of GHGE is also estimated from data centres, estimated from 33% in 2010 to 45% in 2020. Referring the online tool named as the Cambridge Bitcoin electricity consumption index, Baraniuk (2019) also states that in 2019, Bitcoin uses nearly the same amount of energy as the whole nation of Switzerland, and reaches to 7 GW of electricity (0.21% of the total electricity supply for the whole world). Therefore, it is essential, to increase the momentum of Green IT research to improve the computing resource allocation and performance efficiency which in turn reducing the GHGE from ICT usage.

Academically, many articles have been published in the Green IT-related research area since the 1980s. However, the electricity consumption from ICT usage has been dramatically increasing over the last few decades. As a result, its contribution to GHGE has been accelerating. It is crucial to understand how Green IT research has been progressing and identify the areas for improvements. This study is aimed to provide a holistic and quantitative overview of Green IT publications by applying the bibliometric analysis along with co-authorship and citation network analysis. One of the objectives of this study is to evaluate the current research progress on Green IT and the academic collaborations among academic institutions and countries. It also aims to discuss the potential research directions for further studies derived from findings from this study.

This book chapter is organised as below. After the introduction section, research methods and data collection process will be described in Sect. 2. Then empirical findings from bibliometric analysis, co-authorship and citation networks analysis will be presented in Sect. 3. In the last Sect. 4, the research conclusion will be drawn to recommend further studies.

2 Methods and Data

In this paper, bibliometric analysis, co-authorship and citation network analysis are applied to provide the overview of Green IT literature and current trends in its publication and collaboration. The detailed explanation on these data analysis methods and how Green IT publication data is collected from Web Of Science database will be provided in this section.

2.1 Methods

Pritchard (1969) defined the bibliometric analysis as applying the mathematics and statistical methods to conduct the literature review on previously published books and other media of communications. Before Pritchard, statistical bibliography analysis was used in health science, and Raisig (1962, p. 450) defined it as "*assembling and interpretation of statistics relating to books and periodicals; it may be used in a variety of situations for an almost unlimited number of measurements*".

Citation analysis, along with network analysis of co-citation and content analysis, has been extensively used methods in bibliometric analysis. Pilkington and Meredith (2009), Chen and Ho (2015), Mao et al. (2015a, b), Zhi et al. (2015), Zhou et al. (2007) state that citation analysis in accompany with network analysis of co-citation data can be used to identify the significant publications, its evolution overtimes, the core literatures, mostly researched countries, the primary knowledge groups, their evolutions in terms of their research popularity, the impacts of scholars and the relationship between citing and cited works in a particular studied area. On the other hand, content analysis can be used to identify the current popular research topics or themes or trends or issues based on the frequency of keywords and other distributions, Gao et al. (2016). According to Gao et al. (2016), network analysis can be used to classify the network of publications (as nodes), and inter-relations among them and this publication/citation networks can be used to examine the importance and influences of a publication based on its centrality and connectivity with other publications (nodes). In this study, network analysis will be conducted as a citation network analysis which illustrates research articles, organisations and countries, and also co-authorship network analysis based on authors, organisations and countries. The findings from these network analysis will evaluate the influence and importance of a node; representing research articles, authors, organisations and countries, by measuring the centrality and connectivities of these notes.

In this study, VOSviewer is used to visualise the results from co-authorship and citation network analysis. These co-authorship and citation network analysis are undertaken to evaluate the academic collaboration among various authors, organisations and countries. In these network analysis map, each node represents the author or organisations or country. A network link is a connection or relation between two nodes, and the strength of each link represents the number of publications two authors have co-authored (in co-authorship network analysis). Waltman et al. (2010) state that the weighted variant of modularity-based clustering method is applied in VSOviewer to group the nodes.

2.2 Data Collection and Treatment

In this study, the Web of Science database is used to extract the literature dataset because it provides a comprehensive and wide range of journals and other publications access. "Green IT", "Green IS", "Sustainable IS" and "Sustainable IT" are used as keywords to search the related publications from 1994 through 2019. The subject areas included in this search are computer science information systems, environmental sciences, computer science theory methods, management, environmental studies, computer science software engineering, green sustainable science technology, business, telecommunications, social sciences interdisciplinary, computer science interdisciplinary applications, computer science hardware architecture, multidisciplinary sciences, computer science cybernetics and computer science artificial intelligence in order to provide how Green IT has been discussed in the computing areas. The search was conducted in December 2019, and 909 publication results are listed during the period 1994–2019. Of all these retrieved documents, journal articles are accounted for 55%, followed by conference proceeding papers (39%) and editorial materials 4% as shown in Fig. 1.

Of these 909 publications, English 97.03% is the most frequently used language, followed by Portuguese, which accounted for 2.2%. Some articles are published in other European languages such as German, Italian and Spanish. All of these 909 publications are included in further analysis in order to provide an international perspective.

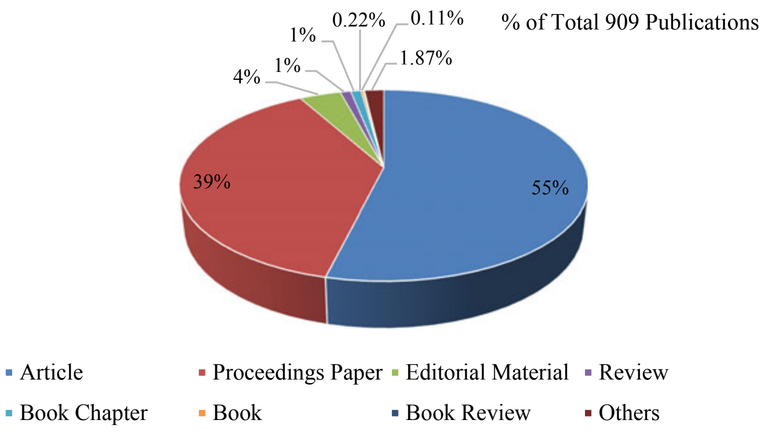

Fig. 1 Numbers of publication by document types

In regards to counting the national property of a paper, it depends on where its first author comes from when multiple authors could be from various countries. The full address of its first author is taken into consideration for identifying his/her country. There could be some various keywords for the same meaning, for example, “public transport” and “public transit”. Both “Green IT” and “Green IS” were used in the search and “Sustainable IT” and “Sustainable IS” because these keywords are interchangeable terminologies. In addition, digital object identifiers (DOI) are used to standardise the citations in various referencing styles.

3 Results and Discussions

In this section, the findings from bibliometric analysis will be discussed first to provide the overview and trends in Green IT publications and to highlight the journals, articles and countries which are high performing in this Green IT research area. Then findings from coauthorship and citation network analysis will be explained to identify which academic institutions and countries are collaborating more than others, and also their citation performance.

3.1 The Performance of Related Publications

Figure 2 presents the total number of published articles and average citations per year per article between 1988 and 2019. Several publications for Green IT significantly increased since 2008, then experienced a significant increase in 2010 and 2011. In 2010, some researchers from Japan, such as Enokido et al. (2010) researched to develop the algorithm and models on power saving with peer to peer systems. At the same time, Dedrick (2010) also raised the awareness of Green IS in terms of its concepts and issues. In 2011, the highly cited agenda for Green IT and systems research was proposed by Tracy Jenkin and her colleagues.

Meanwhile, a research group led by Viet Dao also developed the highly cited from green to sustainability: information technology and sustainability framework. Then it reached its peak at ninety-nine publications in the year 2013. It is noticeable that there is a slight decrease in its publications in 2015, again in 2018 and 2019. Nevertheless, the average citation per year per article has remained stable since 1997.

Figure 3 illustrates the numbers of citations and top three published countries from 2004 to 2019. An increase in the numbers of citations in Fig. 3 also aligns with the increase in numbers of publications Fig. 2 between 2010 and 2019. Nevertheless, there is a slight decrease in the number of citations in 2019. Since the highly cited deterministic algorithms and adaptive heuristics to improve the resource allocation and performance efficiency in cloud data centres were published by Beloglazov and Buyya (2012), Beloglazov et al. (2012), Australia has reached in the annual first highest cited country since 2013. It is noticeable that Australia, the United Kingdom

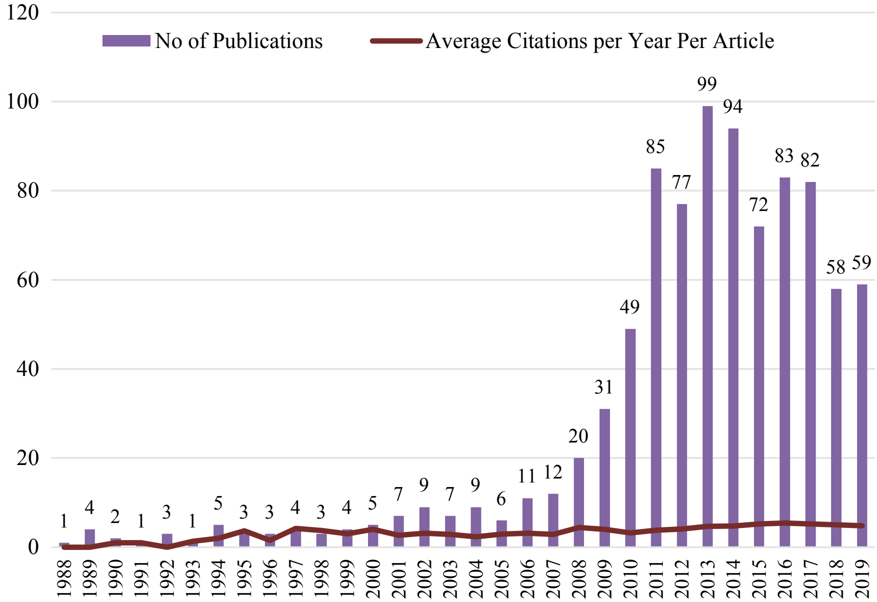

Fig. 2 Numbers of publications and average citation per year per article during the period of 1988–2019

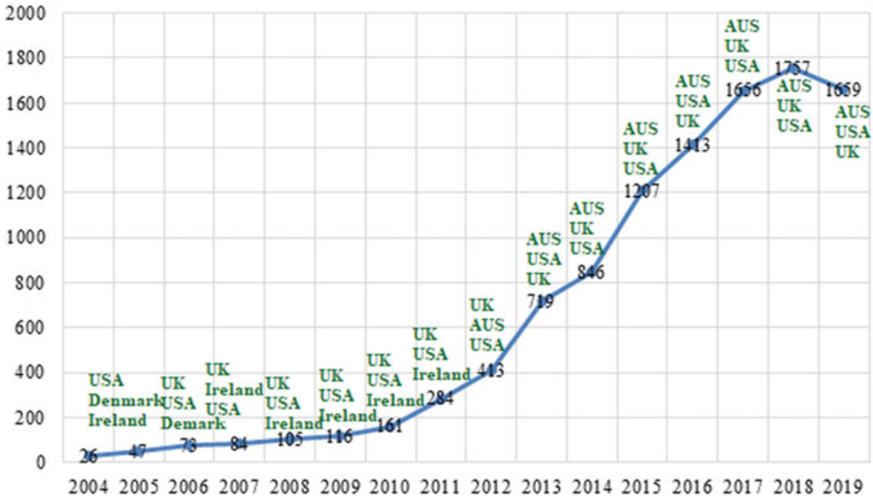

Fig. 3 Numbers of citations and the top three cited countries

and the United States of America have remained the status in the top three cited countries since 2012.

3.2 Journals' Performances

The collected 909 articles were published in 696 various journals or conference proceedings indexed in Web of Science. It indicates the expanded nature in publication distributions and the broad interests of various journals and conferences. The number of articles published in top 15 sources contributes to 17.05% of total publications. Among all of these document sources, Sustainability is the most published journal with 26 (2.86%) articles. Among these document sources, Journal of Cleaner Production and Computer are the two influential journals with high H-index above 150. Some of the highly cited articles, proposing the algorithms and models to improve the resource allocations and performance and energy efficiency for high-performance cloud computing centres, were published in Future Generations Computer Systems: The International Journal of E-Science which has high H-index 93 (Table 1).

Table 1 The top 15 journals or related conferences

Source titles	Records	%	H-index
Sustainability	26	2.86	53
Journal of Cleaner Production	16	1.76	150
Australasian Journal of Information Systems	12	1.32	12
Communications in Computer and Information Science	12	1.32	40
New Scientist	12	1.32	17
Computer	11	1.21	153
Communications of the Association for Information Systems	10	1.1	38
Journal of Strategic Information Systems	8	0.88	76
Proceedings of the Annual Hawaii International Conference on System Sciences	8	0.88	72
Advanced Science Letters	7	0.77	24
Future Generation Computer Systems: The International Journal of E-science	7	0.77	93
IFIP Advances in Information and Communication Technology	7	0.77	44
Information Systems Frontiers	7	0.77	55
IT Professional	7	0.77	42
Business Information Systems Engineering	5	0.55	37

3.3 The Most Cited Articles

In this section, the top fourteen cited articles during the last decade 2009–2019 are explored. The total numbers of citations imply the academic values of each article. Sometimes, the number of citations can heavily rely on the number of researchers or groups working on a particular research topic.

Figure 4 shows two significant evolution trends of the first and second most cited articles after they were published, Beloglazov et al. (2012) and Beloglazov and Buyya (2012). Their deterministic algorithms and adaptive heuristics to improve the energy and performance efficiency have been highly cited till now even though there is a slight decrease in the number of their citations in last two years 2018 and 2019. Both of these articles significantly contributed to energy-saving and efficient performance in cloud data centres and added significant values in Green IT development area. They are followed by the articles describing the flow optimization-based framework to reduce the workload and carbon emissions from request-routing and traffic engineering, Gao et al. (2012). It is noticeable that not only the articles relating Green

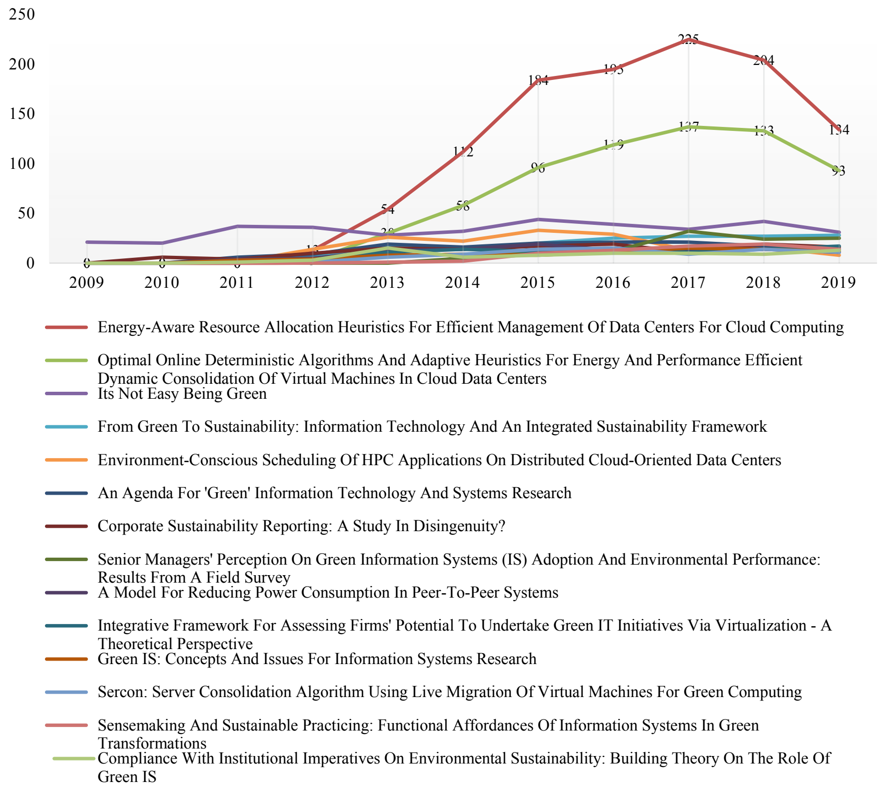

Fig. 4 The most cited articles

IT development but also the articles emphasising on its deployment are also significantly contributing to this Green IT research area. An article, proposing information technology and an integrated sustainability framework, was published by Dao et al. (2011). This paper suggests how IT can contribute to sustainability more than for reducing energy consumption from IT systems. This paper has been the fourth highly cited and the number of its citation has been steadily increasing since its publication.

3.4 Countries' Performances

The number of publications from one country indicates the support and attention that this country has in the related research topics. Only the resided country of the first author at the time of publication is considered in this analysis.

Figure 5 shows the top 15 most productive countries, which have published significantly in Green IT research area. These top 15 countries published a total of 766 articles which accounted for 84% of the total searched articles, which includes USA (139 articles, 15.3%), Germany (80 articles, 8.8%), India (60 articles, 6.6%), Australia (57 articles, 6.3%) and England (57 articles, 6.3%). Among all the productive countries, USA is the most productive country and is leading the Green IT research area. European countries are also contributing significantly, and six out of the top 20 countries are from Europe. Furthermore, the Asia-Pacific counties (Australia, China, Malaysia, South Korea, Japan, Taiwan and Indonesia) are making a significant contribution to

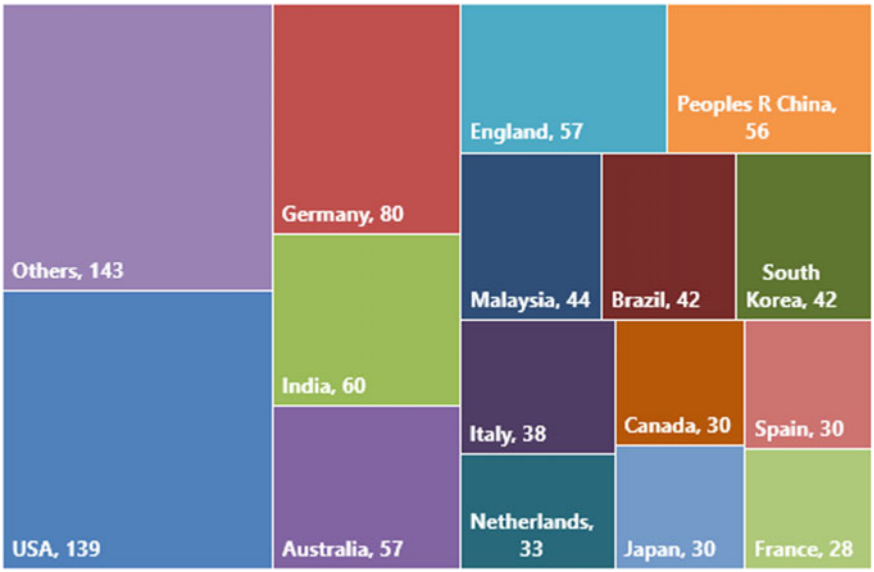

Fig. 5 The top 15 most productive countries

Green IT-related publications, accounted for 27.83% of the total articles included in this study.

3.4.1 Funding Agencies

The number of publications supported by funding agencies shows how well the governments or regional agencies have the interest and encourage their scholars in a particular research area with their high research priority.

Figure 6 illustrates the top twenty funding agencies which supported to conduct research and publish the articles on Green IT from 1988 through 2019. Two hundred fifty-two funding agencies supported to publish 200 articles which are included in this study. Funding agencies information were not reported for others 709 (78%) articles. The most funded agency for the research on Green IT during the period 1988–2019 is National Natural Science Foundation of China, supported for 15 publications. Other funding agencies from China are the National Social Science Foundation of China, China Postdoctoral Science Foundation and National Basic Research Program of China and their contributions accounted for 4, 3 and 3 publications, respectively. Even though China is not the most published country, as shown in Fig. 5 but funding agencies from China have been reported as the most contributed ones for the articles included in this study. European Union EU contributed to 14 publications and ranked the second among the most funded agencies. It is followed by the Ministry of Education Culture Sports Science and Technology Japan MEXT and National Science

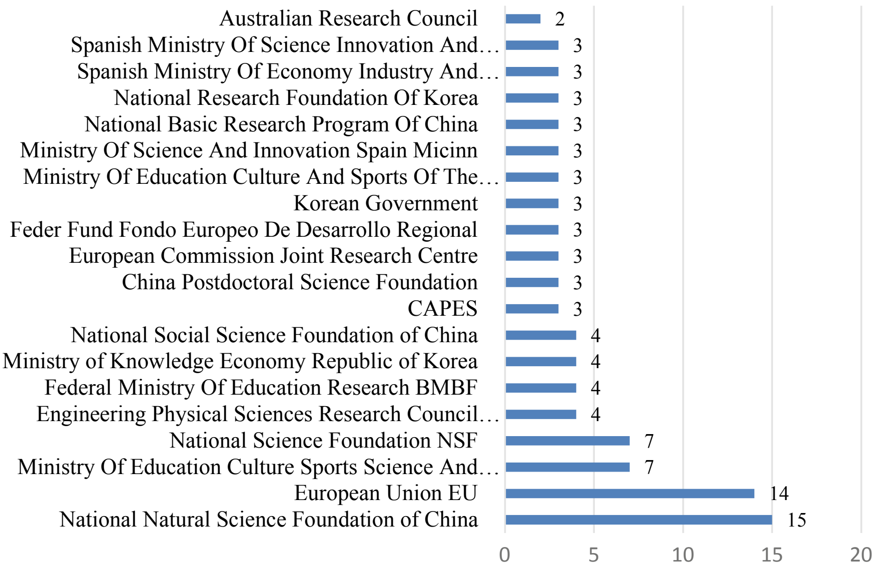

Fig. 6 Top funding agencies during the period of 1988–2019

Foundation NSF where each of them supported seven publications, reflecting that MEXT and NSF need to make more efforts.

3.5 *Co-authorship Network Analysis*

In this section, the findings from the co-authorship network analysis will be discussed in terms of academic cooperation and collaboration among countries.

3.5.1 Academic Cooperation

The research collaboration among academic institutions is essential and valuable to accelerate the progress of a particular research topic or area.

Figure 7 illustrates the highly collaborative academic institutions for Green IT research area. It is clear that the University of Liechtenstein has the highest collaboration network links, compared to other academic institutions which published the Green IT related articles; 909 articles included in this study. However, the link of the University of Liechtenstein is only 5. According to Van Eck and Waltman (2009), the link of co-authorship means the number of co-authorship between the University of Liechtenstein and other academic institutions. Professor Stefan Seidel, the University of Liechtenstein, collaborated with other researchers from various academic institutions for the five highly cited Green IT related articles. These articles are (a) Green IT: A Matter of Business And Information Systems Engineering? (Loos et al. 2011), (b) Sensemaking And Sustainable Practicing: Functional Affordances Of Information Systems In Green Transformations (Seidel et al. 2013), (c) IT-Enabled Sustainability Transformation-The Case Of SAP (Seidel et al. 2014), (d) The Sustainability Imperative In Information Systems Research (Seidel et al. 2017) and (e) Design Principles for Sensemaking Support Systems In Environmental Sustainability Transformations, (Seidel et al. 2018). Among these articles, the second article is the highest cited one which proposed the theoretical framework identifying four important functional affordances. This framework highlights how an organisation and individual can imply

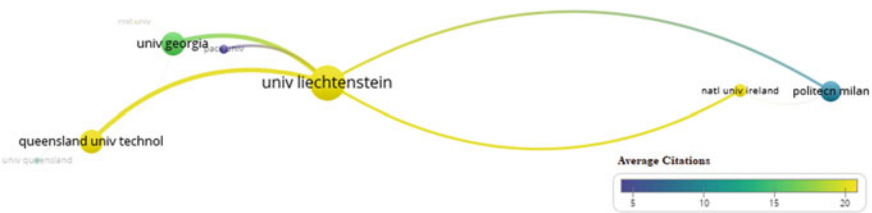

Fig. 7 The highly collaborative academic institutions

more environmentally sustainable approach by using the information systems. Additionally, the University of Georgia and Queensland University of Technology are the second-highest collaborative academic institutions in Green IT research area with four co-authorship links.

3.5.2 Collaboration Among Countries

The academic collaborations among various countries are essential to enhance the momentum in seeking an innovative solution and to improve the research progress. Figure 8 indicates the academic collaborations among various countries for Green IT publications from 1988 to 2019. The top ten most collaborative countries for Green IT research area are the USA, Germany, India, Australia, China, England, Malaysia, South Korea, Brazil and Italy. The researchers from the USA have most co-authored with their colleagues in Germany, China, India, South Korea, Australia, England, Italy and Netherland and its number of articles co-authored with others reached to 137 during 1988–2019. Among these academic collaborations, co-authored publications from Australia researchers have the highest citations accounted for 2584, followed by USA (2133), England (1489), Germany (598) and Canada (579), reflecting that

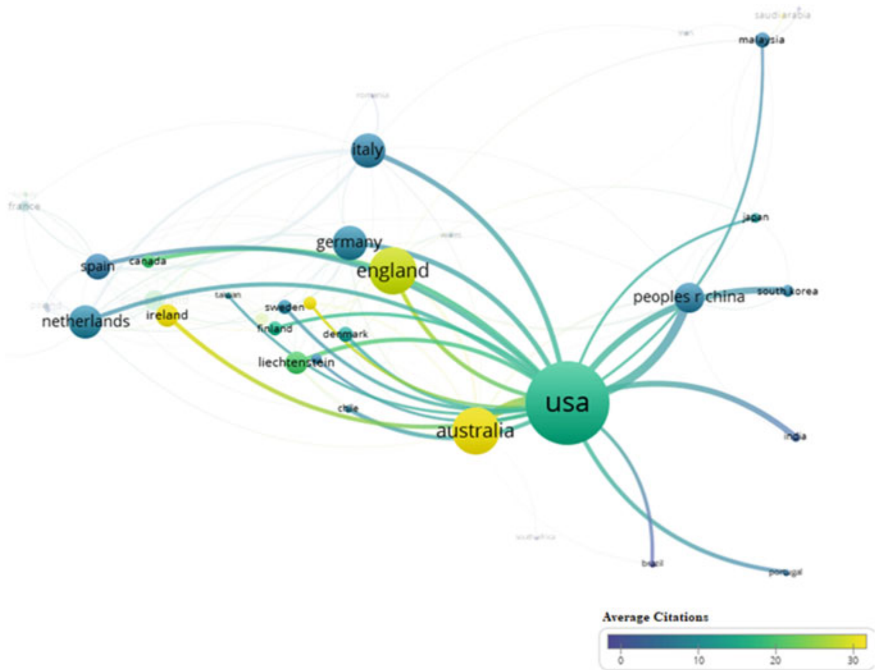

Fig. 8 The academic collaborative relationships among 40 countries

these academic collaborations are contributing the high academic values for Green IT research areas.

3.6 Citation Network Analysis

In this section, the findings from citation network analysis will be discussed in terms of citations among documents, sources and countries.

3.6.1 By Documents

In this citation network analysis, all 909 Green IT related articles (collected for this study) are clustered by using the weighted variant of modularity-based clustering method first. Then citation links between each pair of articles are established.

Figure 9 shows how each Green IT related articles are citing each other. The size of circles in Fig. 9 represents the number of a citation for an article, and the colour of the circle represents its published year according to the shown colour scale. Nearly at the end of the twentieth century, Walley and Whitehead (1994) highlighted the complexity and the urgent need to address the environmental challenges in the organisations by utilising the information systems to track and disseminate emissions data on the cross-functional basis for better decision making on the trade-off between cost and environmental control. Their article has been highly cited since its publication also in the strategic management research area, followed by a highly cited article from Telle (2006). He suggested that other important factors should also be considered rather than claiming the different effect of environmental performance on economic performance. In addition, Alshuwaikhat and Abubakar (2008) proposed a framework for campus sustainability by integrating Green technology, environmental management, public participation, social responsibility, teaching and research on sustainability and this framework has been well cited. At the end of the first decade in the 21st century, researchers start publishing the algorithm, methods, approaches to improve the resource allocation, performance efficiency and energy consumption for Green IT development. Enokido et al. (2010) published a model to reduce the power consumption in peer-to-peer systems. Even though their work has been highly cited, their focus is more specific for peer-to-peer systems and relative distance from the rest of Green IT related articles. Two articles on resource allocation heuristics and optimal deterministic algorithms were published by Beloglazov et al. (2012) (Beloglazov and Buyya 2012). These two articles are the two highest cited ones among 909 Green IT related articles, (1122 and 672 citations respectively) and contributed significantly to Green IT development for cloud data centers. These articles are highly cited in other computational research topics. At the same times, other researchers such as Jenkin et al. (2011), Dao et al. (2011), Gholami et al. (2013),

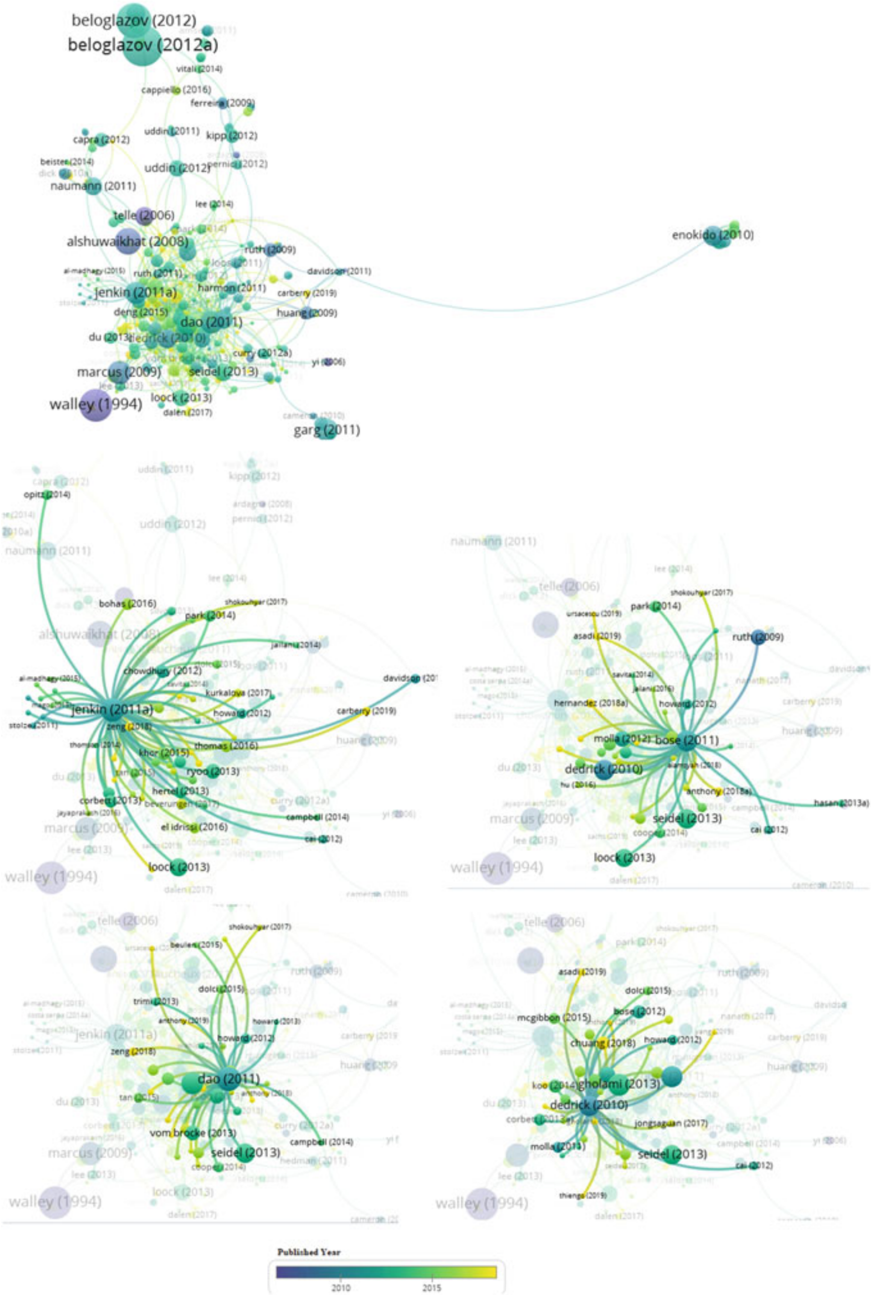

Fig. 9 Citation network analysis by documents

Fig. 10 Citation network analysis by sources

Bose and Luo (2011) and Dedrick (2010) more emphasised on developing frameworks for Green IT implementation. These articles have been well in later Green IT related articles, as shown in Fig. 9.

3.6.2 By Sources

It is also essential to understand what are the publication source that Green IT scholars are referring or citing more than others and also how this citation trends progress over time. The citation network analysis by the source is useful to provide this insight.

In Fig. 10, the size of circles represents the total number of citations from a particular source, and its average published year is illustrated as in the colour scale bar. In terms of citations by source, the Journal of Strategic Information has been highly cited by others such as the Information Systems Frontiers, the Communications of the Association for Information Systems, the Sustainability and the Australasian Journal of Information Systems at the early period of 21st century. In the midst of the 21st century, the number of citations shifts to the articles, published in the Information Systems Frontiers, the Communications of the Association for Information Systems and the Ecological Economics are the journals. Later, there have been more Green IT related articles published in and cited from the Journal of Cleaner Production and the Sustainability.

3.6.3 By Countries

As another perspective, the citation network analysis by the countries is valuable to understand the publications from which countries are cited more and how they are connected or linked together.

The size of the circle represents the number of documents published by scholars in a particular country and the average citation for each country is shown as in the colour scale bar in Fig. 11. Even though researchers from the USA have published most, the average citation for articles published by Australian scholars (as the first author) is significantly higher, followed by the ones from England.

Additionally, these three countries have been in the core of the Green IT-related citation network. It is interesting to note that the number of published articles is

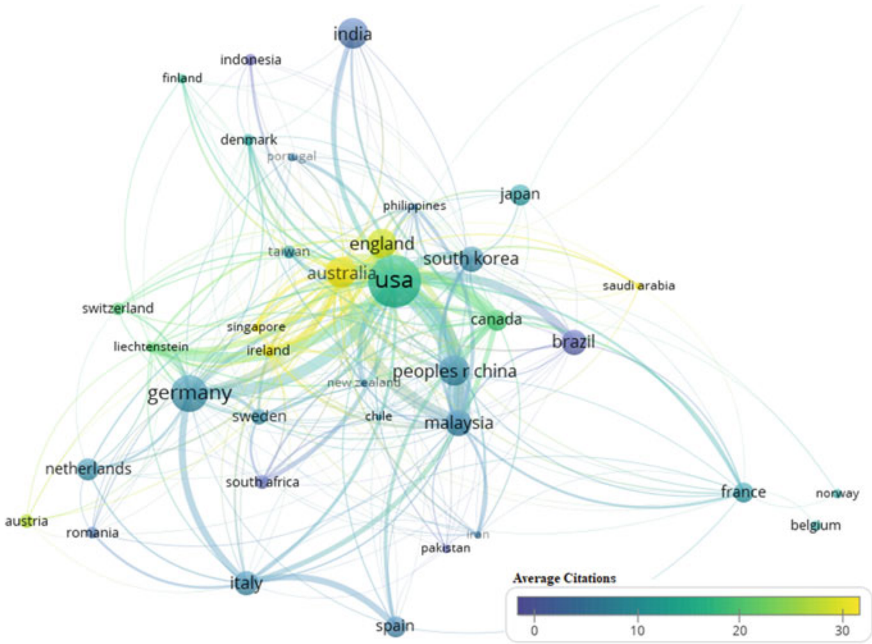

Fig. 11 Citation network analysis by countries

not comparatively high, but their average citations are significantly high for authors from Singapore, Ireland and Saudi Arabia. The European Union is the second-highest funding agencies for Green IT research and its substantial contribution reflects on the high number of Green IT-related publications from Germany, Italy, Spain, Netherlands, Sweden, France, Romania, Switzerland and Liechtenstein. Although citations of articles from Germany is well linked with the articles from other European nations such as France, Netherlands, Italy, Spain, Sweden, Switzerland and Liechtenstein, the articles from Norway and Belgium are only linked with the ones from France. This citation network illustrates that countries from all continents are well linked with each other, except Wales, Norway, Belgium and Austria.

4 Conclusions and Future Research Directions

The Green IT research has made significant progress since the 1980s and accelerated from 2008 to 2013. Since then its progress has been gradually decreasing in the last few years. The supports of funding agencies from the USA, UK and Australia are relatively low compared to funding agencies from the EU and China, highlighting the needs of their more efforts. According to co-authorship network analysis, the academic collaboration links among academic institutions or countries are not strong, and it is necessary to encourage the co-authorship to share experiences, skills and ideas for more innovative solutions. From citation network analysis, two main research areas for Green IT is its development with improved algorithms for resource allocation and energy efficiency and its deployment with integrated framework or approach. It is also vital to enhance the awareness of sustainability, and Green IT and academic institutions play essential to the role to change the students' mindset by incorporating the sustainability and Green IT concepts in the curriculum (Issa and Issa 2017) and by paying more attention to research on Green IT awareness.

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A Mauritian Case Study of IT Governance and Green IT

Sarita Hardin-Ramanan

Abstract From its small size to its resource constraints and vulnerability to climate instabilities, the Small Island Developing State of Mauritius faces multiple obstacles in its journey from an upper middle-income to a high-income economy. As highlighted in its 2030 Vision, the key to overcoming these issues lies in a digital and environmentally sustainable Mauritius. Organisational Information Technology (IT) needs to progress from its traditionally reactive function to a more pro-active, strategically aligned position. The effective governance of IT and Green IT is thus essential to maximise IT value in boosting productivity and sustainable practices within both the public and private sector. This chapter discusses the Mauritian legal and strategic environment through an IT governance and Green IT prism. With IT ranking high on the Mauritian government agenda, several laws and strategic plans were found to drive robust IT solutions for ecological and effective processes. However, many do not explicitly highlight the vital role of IT Governance and Green IT in effective IT use. The Mauritian legal framework, National Code of Corporate Governance, as well as national policies and plans therefore warrant improvement to further encourage the adoption of IT governance and Green IT measures for a green, digital Mauritius.

Keywords IT governance · Green IT · Regulatory framework · The national code of corporate governance · National plans and strategies · IT security · IT audits · Digital mauritius

1 Introduction

Strategically situated in the middle of the Indian Ocean, Mauritius is an upper middle-income economy with a population of around 1.3 million inhabitants and a total area of 1,979 km^2 (Statistics Mauritius 2017c). Since its independence in 1968, the island has experienced multiple economic shifts ranging from a mono-crop sugar industry in the 1970s, to a prominent growth of its manufacturing and tourism sectors in the

S. Hardin-Ramanan (✉)
Curtin Mauritius, School of IT, Moka, Mauritius
e-mail: sramanan@curtinmauritius.ac.mu

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1980s, and a change of millennium characterised by a strong focus on financial and IT services (Statistics Mauritius 2017c). Though termed as an economic success story (Zafar 2011; Tandrayen-Ragoobur and Kasseeah 2018), the island has its fair share of challenges. The Small Island Developing State (SIDS) of Mauritius is constrained by limited resources, is highly vulnerable to the dangers of climate change and depends heavily on international trade (UNDESA Division for Sustainable Development 2014). Its economic growth has been stagnating between 3.5 and 4% since 2015 (Statistics Mauritius 2018), and the Mauritian government is conscious of the need to revitalise its industries for a resilient, productive and sustainable economy.

One of the key solutions appears to reside in a strong move towards a digital economy. In 2016, the International Telecommunications Union ranked Mauritius first in Africa for Information and Communication Technology (ICT) development with an ICT development index (capturing ICT-readiness, intensity and capability) of 6.02 as opposed to 5.67 in 2015 (Statistics Mauritius 2017b). In 2018, ICT became the third pillar of the Mauritian economy with an annual GDP contribution of 5.6% predicted to rise to 10% by 2030 (Ministry of Technology Communication and Innovation 2018). The following government strategies/declarations aimed at boosting Mauritian industries continue to fuel this drive for ICT development:

1. The Digital Mauritius 2030 plan for the development of smart and intelligent processes to improve public sector effectiveness and business IT capability (Ministry of Technology Communication and Innovation 2018).
2. The Mauritius Vision 2030, which aspires for excellence in governance, IT and sustainability (*MAURITIUS VISION 2030* 2017).
3. The Mauritius AI Strategy (Working Group on Artificial Intelligence 2018), which focusses on AI and other emerging technologies such as Blockchain and the Internet of Things (IoT) for improved productivity.
4. The Mauritian Prime Minister's Budget Speech 2018–2019 (2018), which reflects a strong commitment towards economic digitalisation.

These strategies can only show promise if both the public and private sector buy in. Government and businesses understand the importance of Information Technology (IT) for productivity improvement and growth, but without strong IT governance, IT decisions might not always align with or facilitate organisational strategies. Strategic IT direction and board oversight are thus key to maximize IT potential and prevent it from being relegated to its traditionally reactive, under-utilized function.

In addition to its focus on digitalisation and growth, environmentally sustainable development features high on the Mauritian government agenda. The island ranks 13th among countries with the highest disaster risk and 7th among island states most exposed to natural hazards (WorldRiskReport Analysis and prospects 2017). From 2016 to 2017, Mauritius experienced a 3.3% rise in net Greenhouse gas (GHG) emissions and a total carbon emission increase from 4,087 to 4,226.2 thousand tonnes (Statistics Mauritius 2017a). In 2008, the "Maurice Ile Durable" initiative was launched for a greener Mauritius; thus giving a new thrust to sustainability concerns among government, business and the community at large (*Maurice Ile Durable* 2013). Since then, the Mauritian government has continued to put emphasis on sustainable development. For example, in its 2015–2016 budget, measures for pollution prevention, cleaner production and energy efficiency were announced (Budget Speech 2015–2016 2015). Subsequent budgets (Budget Speech 2016–2017 2016; Budget Speech 2017–2018 2017; Budget speech 2018–2019 2018) continued to identify measures to support a green Mauritian economy. These include the adoption of ecological sources of energy and tax exemptions for renewable energy projects. Green development also underlies the Mauritius 2030 vision in which the island commits to a reduction in GHG emissions (*MAURITIUS VISION* 2030 2017). This commitment was further reinforced in 2015 through the signing and ratification of the United Nations Paris Climate Agreement (Government of Mauritius 2015), and the adoption of the United Nations Sustainable Development Goals (Statistics Mauritius no date).

Unfortunately, the role of ICT in this quest for sustainability does not appear sufficiently pronounced. With only a few isolated Green ICT guidelines and workshops from the National Computer Board and a National Green ICT Policy (Ministry of Information and Communication Technology 2013) which, since 2013, remains in draft stage, initiatives to promote Green ICT on the island have been scant. ICT has also proven to be cause for environmental discomfort. Along with its energy consumption and associated carbon emissions, managing the growing amount of e-waste has been problematic. Annually, an average of over 10,000 tonnes of e-waste (Ministry of Information and Communication Technology 2013) is estimated to be produced in Mauritius and their clean disposal is critical. Green IT governance is thus crucial for the island to meet its goal of an environmentally sustainable, digital economy.

Like other SIDS, Mauritius is highly dependent on its IT to boost its position in Africa and the wider global market. The Mauritian government thus aspires to build an economically stronger, digital Mauritius, while consistently committing to green development budgets (Budget Speech 2016–2017 2016; Budget Speech 2017–2018 2017; Budget speech 2018–2019 2018). To catalyse this vision of a smart and sustainable Mauritius, both public and private organisations should be encouraged to adopt robust IT governance and Green IT (ITG) measures. This chapter therefore explores the Mauritian regulatory and strategic environment supporting the governance of IT and Green IT on the island. Current legislations directly or indirectly relevant to strategic and sustainable IT oversight are first discussed, before moving to the National Code of Corporate Governance and documented plans for an environmentally friendly, digital Mauritius.

2 The Mauritian Regulatory Framework

The Mauritian regulatory framework mildly caters for responsible and ecological IT governance. Laws appear to focus primarily on good governance practices with emphasis on risk management, audits and disclosure, with some of them including IT. Mandatory guidelines from the Bank of Mauritius (BOM) further regulate the financial sector and, though not solely IT-specific, stress on the implementation and communication of risk management measures, security controls and their audits. Environmental regulations do not explicitly cover IT but, instead, focus on general environmental concerns encompassing ecological IT use and disposal. These include responsible waste management, energy efficiency and the acquisition of green technology. The second edition of the National Code of Corporate Governance also includes some guidance for the effective and environmentally sound governance of IT. The following sub-sections discuss these regulatory requirements in more details.

2.1 Mauritian Laws Affecting IT Governance and Green IT

The Mauritian legal system includes some laws and guidelines covering IT governance principles such as IT security, risk management and their disclosure. For example, the Electronics Transaction Act (2000) emphasises security measures for e-transactions, the Computer Misuse and Cyber Crime Act (2003) terms unauthorised IT data or service access and its manipulation as illegal, and the Data Protection Act (2017) mandates individual data privacy and alignment of data protection frameworks with international standards such as the EU General Data Protection Regulation (GDPR). In addition to the Bank of Mauritius (BOM) Guideline on Internet Banking (Bank of Mauritius 2001), Operational Risks (Bank of Mauritius 2008) and Corporate Governance (Bank of Mauritius 2012), the Insurance Act (2007) also dictates IT security controls and audit. The BOM guidelines for Public Disclosure (Bank of Mauritius 2009) further encourages banks to share their risk management (including IT) structures with their shareholders.

On the other hand, the legislation of environmental responsibility on the island appears more generic and less IT-specific. For example, the Environmental Protection Act (2008) promotes general ecological behaviour and its derived Industrial Waste Audit Regulation (2008) promotes clean waste (including e-waste) disposal. While again not specific to Green IT, the Income Tax Regulations (2017) come close by mandating 50% company tax rebates on green technology, and the Energy Efficiency Act (2015) encourages energy-efficient behaviour. Under this act, a company might need to submit an independent energy audit report to demonstrate environmentally responsible energy management. In such cases, Green IT solutions would be useful to support energy-efficient behaviours.

2.2 The National Code of Corporate Governance

Beside laws, companies in Mauritius also need to abide by the Mauritian National Code of Corporate Governance. In its second edition (National Committee on Corporate Governance 2016), the code adopts an “apply and explain” methodology whereby businesses concerned are required to implement guidelines prescribed by the code and document details of their application in their annual reports. Principle 4 of the code is the only one, which overtly recommends IT governance practices. For example, it mentions that the board of directors should be responsible for the company Information Strategy, Information Technology and Information Security governance to ensure that IT investments strategically align with the company vision and objectives. To assist in effective IT governance, principle 4 encourages the set-up of an IT steering committee comprising of both business and IT representatives. It also specifies robust IT security, effective IT policy implementation and independent IT audits as a board mandate. Finally, principle 4 recommends the adoption of internationally recognised IT governance frameworks such as COBIT, and requires the governance section of the company annual report to include details of its IT security and investment measures. Although more generic, a few other sections of the code also allude to the sound governance of IT. For example, principle 5 dictates the implementation of an effective risk management system and robust internal controls overseen by the board, whereas principle 7 covers the importance of reliable audits (National Committee on Corporate Governance 2016). Extending these guidelines to IT would help businesses in optimising IT strategic use.

While the code (National Committee on Corporate Governance 2016) does not mention Green IT-specific behaviours, it strongly emphasises the need for environmental governance. Recognising the vulnerability of Mauritius to the perils of climate change, the code highlights the importance of company ecological citizenship through the identification and minimisation of business environmental impacts, as well as the dissemination of environmental awareness. Board responsibility for the environment should thus be translated into enterprise sustainability values as well as green reporting. This is reflected in principle 6, which requires the board to provide clear and comprehensive environmental governance reports using key performance indicators to report on energy efficiency and CO_2 emissions. In addition, annual reports should include details of actions taken by the board to monitor and control ecological impacts including the organisational carbon footprint. As guidance for companies registered on the Stock Exchange of Mauritius (SEM), the code mentions the SEM Sustainability Index (SEMSI) used to track sustainable (including environmentally sustainable) practices. The SEMSI aligns with international best practice and provides a good indication of business sustainability to responsible stakeholders such as potential investors (National Committee on Corporate Governance 2016). Green IT practices promoting the acquisition, usage, maintenance and disposal of environmentally friendly information technology, as well as the adoption of IT solutions to facilitate green behaviours and processes would therefore be useful to help businesses abide by the environmental exigencies of the code.

3 National Plans and Strategies

In addition to Mauritian regulations and codes, the government has devised several national plans and strategies to achieve its vision of a green and digital economy. These are analysed next through an IT governance and Green IT lens.

3.1 National ICT Strategic Plan 2011–2014

The National ICT Strategic Plan (NICTSP) 2011–2014 (Gillwald and Islam 2011) succeeds its 2007–2011 (2007) counterpart which reflected the Mauritian government's ambition to not only boost IT use across all economic sectors, but to also transform Mauritius into a leading, regional ICT hub. The plan defined a total of 124 projects which were reviewed under the NICTSP 2011–2014 (Gillwald and Islam 2011). As realisation of the unrealistic scope and constrained budget of the 2007–2011 national ICT strategies dawned, the reviewed 2011–2014 strategic plan focussed mostly on priority projects with IT security being one of them. For example, CERT-MU (Computer Emergency Response Team of Mauritius) was set up under the aegis of the National Computer Board (NCB) to respond to IT security incidents, as well as spread information security awareness and guidance on the implementation of Information Security Management Systems as per ISO 27001 guidelines. To further support businesses in aligning with the second edition of the National Code of Corporate Governance, CERT-MU also assists in IT security audits and training for IT managers and CIOs (National Computer Board, no date). Additionally, the Mauritian Information and Communication Technology Authority (ICTA) established a Public Key Infrastructure (PKI) framework to reinforce security and trust in electronic transactions.

As recommendations, the NICTSP 2011–2014 (Gillwald and Islam 2011) highlighted the need to review the legal mandate for improved IT business engagement as a prime strategic area of intervention. Acknowledging the role of IT in environmental sustainability, the plan also suggested the formulation of a National Green ICT policy. However, except for its two suggestions and focus on IT security, the NICTSP 2011–2014 (Gillwald and Islam 2011) contained little emphasis on the governance of IT and Green IT on the island.

3.2 Digital Mauritius 2030 Strategic Plan

The Digital Mauritius 2030 Strategic Plan (Ministry of Technology Communication and Innovation 2018) succeeds the NICTSP 2011–2014. Based on input from both public and private sector stakeholders, the plan aims at further leading Mauritius towards a digital economy. The document identifies the Mauritian legal framework, security risks and the lack of resources as major barriers to effective IT adoption, and promotes IT innovation, data protection and privacy, as well as a consolidated legal framework for a smart, digital Mauritius. The Mauritian government and businesses can only derive optimum value from the proposed solutions if their IT is strategically governed to drive innovative, efficient and sustainable solutions. Effective and green IT governance is therefore key to achieving the 2030 digital vision for Mauritius.

Digital Mauritius 2030 (Ministry of Technology Communication and Innovation 2018) highlights the need to strengthen national policies and promote an ICT governance strategy for a transparent, robust and productive technological ecosystem. The plan pinpoints data privacy, IT security, smart procurement and strong leadership supported by effective governance frameworks as key principles underlying the successful move towards a digital government. Following the NICTSP 2011–2014 (Gillwald and Islam 2011) recommendation to amend the Mauritian legal framework for IT security reinforcement, the Digital Mauritius 2030 Strategic Plan (Ministry of Technology Communication and Innovation 2018) also proposes that CERT-MU be established as a single, converged legal entity with the aim of reconciling varying regulations. To further support the Data Protection Act (2017), the strategy underlines the role of the Data Protection Office (DPO) as data privacy regulator where Data Controllers and Processors register prior to storing or processing any personal data. The government additionally envisages simplified, harmonised and streamlined processes for effective flow of information across systems. These standardised procedures would support data sharing and integrity for both efficient and environmentally responsible productivity. In order to promote sound IT governance in the public sector, Digital Mauritius 2030 (Ministry of Technology Communication and Innovation 2018) recommends the adoption of a standard ICT project management methodology across ministries, as well as the establishment of a Digital Government Steering Committee to oversee government ICT projects.

Digital Mauritius 2030 (Ministry of Technology Communication and Innovation 2018) also recognises the key role of latest IT trends such as IoT and Artifical Intelligence to promote an energy-efficient, carbon-free and sustainable economy, while warning organisations against potential resulting traps including excessive e-waste and its poor management. The plan supports the use of IT to promote paperless systems and electronic payments. In addition, it recommends the set up of a National Certification Authority to issue digital signatures, and the implementation of data analytics to monitor and improve the quality of electronic transactions. This would induce greater trust in digital processes and, thus, further encourage Green IT practices in Mauritius.

On the other hand, Digital Mauritius 2030 (Ministry of Technology Communication and Innovation 2018) highlights lack of expertise and IT labour shortage as prime deterrents to the implementation of innovative and environmentally responsible IT solutions. To address this issue, the plan emphasises talent management as a key strategic wave to boost human capability through rigorous training schemes and incentives.

3.3 The 'Maurice Ile Durable' Policy, Strategy and Action Plan

Launched by the Prime Minister in 2008, the 'Maurice Ile Durable' (MID) or Sustainable Mauritius concept is one of the biggest strides taken by the Mauritian government to position the island as a model of sustainability. The MID concept not only responds to a global concern regarding societal imbalances, but it also addresses the extreme vulnerability of Mauritius to climatic instabilities and its heavy dependency on natural resources to meet the needs of its current and future kin (*Maurice Ile Durable* 2013). The MID Policy, Strategy and Action Plan (2013) formalises the Mauritian government's vision for a sustainable Mauritius and builds around the '5 E's': Energy, Environment, Employment/Economy, Education and Equity. The vision centres on efficient energy use across all economic sectors, environmentally friendly behaviours for ecological safeguard, a green economy based on sustainable production and consumption, as well as environmental awareness (Ministry of Environment and Sustainable Development 2013). Despite the island's determination for sustainability, capacity constraints such as a dearth of expertise, technology and capital, have slowed down its progress (Ministry of Environment and Sustainable Development 2013).

Many Mauritian businesses have the means to combat these limitations, and their implementation of Green IT is one of the solutions towards effective use of technology for a sustainable Mauritius. Whilst the MID strategy has little specific focus on Green IT, analysis of the MID strategic plan revealed a number of strategies either driving or warranting Green IT mechanisms. Some of them include energy-efficient processes, green procurement and e-waste management. The MID strategy also promotes public and private sector sustainability engagement through tax incentives on green technology and encourages organisations to support their employees in the implementation of environmentally sustainable practices. Further government initiatives include the establishment of an E-Wastes Management System (Ministry of Social Security National Solidarity and Environment and Sustainable Development, no date) and the setting up of an Energy Efficiency Management Office (*Energy Efficiency Management Office* 2019) to promote efficient use of energy.

Businesses and government are additionally advised to invest in green innovations, acquire green certifications, audit their energy management and report their sustainability initiatives and carbon footprint. Effective Green IT governance can only support organisations in best meeting these strategies.

3.4 The National Programme on Sustainable Consumption and Production (NP SCP) 2008–2013

Sustainable development works in pair with Sustainable Consumption and Production (SCP) patterns. The island thus joined forces with the United Nations Environment Programme (UNEP) to develop the National Programme on Sustainable Consumption and Production 2008–2013 (2008). Energy efficiency and integrated solid waste management figure amongst the key elements of the programme. These entail projects such as energy audits of high-energy industries, and the development of an integrated waste management system. In addition, the National Programme on SCP encourages the adoption of international endorsements for sustainable production such as ISO 14000 for the implementation of Environmental Management Systems and the Green Globe certification of the hotel sector, which certifies efficiency across all hotel processes. The programme also aims at promoting industry environmental reporting using international guidelines such as those prescribed by the Global Reporting Initiative (Ministry of Environment and Sustainable Development 2008).

Green IT governance has a big role to play in this programme. For example, sustainable consumption involves IT energy efficiency, whereas sustainable production includes the use of IT for resource-efficient business processes, as well as environmentally friendly disposal of e-waste. Mauritian public and private organisations are therefore encouraged to adopt Green IT mechanisms to demonstrate their commitment to SCP.

3.5 Mauritius Roadmap for Sustainable Development Goals Implementation

Following its commitment to the United Nations Millennium Development Goals (MDGs) in 2000, Mauritius joined forces with 193 other nations in 2015 to adopt the Sustainable Development Goals (SDGs) defined in the United Nations Agenda 2030 (Statistics Mauritius, no date). Accordingly, the island teamed up with the United Nations Development Programme (UNDP) to formulate a roadmap to guide the implementation of the SDGs.

The Mauritius Roadmap for SDG Implementation (*Mauritius Roadmap for SDG Implementation* 2017) includes actions to fight climate degradations, promote sustainable consumption and production, and encourage the responsible management of natural resources, thereby integrating the achievement of SDGs in its Vision 2030. Through this map, the Mauritian government recognizes the importance of good governance, private sector buy-in and stronger integration of capabilities for improved monitoring and reporting to drive results. Consequently, the government has established a steering committee, which reports to an inter-ministerial coordination committee. The steering committee mandate is to develop and oversee the implementation of strategies as well as the setting up of five working groups, each responsible for a cluster of SDGs, including environmental sustainability and effective governance. To speed up results, the roadmap also identifies accelerators across four dimensions including governance and environment.

In addition, the plan highlights the importance of technological innovation and green development for improved and sustainable productivity. The transition to a green economy warrants acceleration, and the plan recommends the establishment of the right incentives for enterprises and educational campaigns to catalyse behavioural changes. While the government has implemented tax and economic incentives to encourage green practices, there remains room for improvement in some areas. For example, carbon taxes appear missing, and recycling rates need to be increased. The plan also recommends further tax reforms as well as price reductions on green products, and green bonds to encourage investment in environmentally beneficial projects. In addition, it identifies the enforcement of laws and regulations, along with enhanced coordination among different ministries for improved environmental protection. e-Governance also lies at the heart of government service improvement. While the use of ICT in government for more efficient delivery of services started since the 1990s, these can still be improved and their environmental benefits further derived.

None of this can be achieved without the right governance mechanisms, and the roadmap recommends the establishment of a centre of government to integrate, guide, oversee, and create awareness about the different actions implemented. IT and Green IT are not only central to these solutions, but information/environmental management systems are also key to information gathering and analysis for informed decision-making. The effective governance of IT and Green IT is therefore essential in the achievement of these goals.

3.6 Mauritius Artificial Intelligence Strategy

Artificial Intelligence (AI) is at the centre of the government's digital strategy. Realising the economic and environmental benefits of AI, the government formed a working group to draft the Mauritius Artificial Intelligence Strategy (2018) aimed at establishing the way forward for a smart Mauritius. Already, several industries including manufacturing and agriculture have adopted varying levels of AI through remote sensing technologies and smart grids among others. The finance industry is leading the way with the implementation of e-banking and intelligent business solutions, as well as its immersion in the Fintech space. The transportation sector is using road traffic management and weather applications for safer and smarter travelling experiences, and the public sector is looking forward to automate multiple processes for an improved digital service. Such solutions are not only recognized as efficient but they also contribute to significant reduction in energy use and carbon footprint (Working Group on Artificial Intelligence 2018).

Strong governance of IT and Green IT is therefore essential to best capitalise on these benefits. As highlighted in the Mauritius AI Strategy (2018), the Mauritian government is responsible for the establishment of a robust regulatory environment where the adoption of AI is further encouraged through the set-up of fiscal incentives and training grants. With AI applications being increasingly data-hungry, IT governance for the privacy, protection and environmentally friendly storage of data becomes even more crucial. Consequently, the Mauritius AI Strategy (2018) defines the creation of a Mauritius AI Council to further govern and boost the introduction of innovative AI solutions in the country. Strong governance mechanisms are also important to manage the ethical conflicts often resulting from the adoption of AI in order to maintain a balanced relationship between humans and machines. Where required, humans should be able to reverse AI decisions for them to keep an upper hand over machines. This might not be possible without the right IT governance measures.

4 Findings, Discussion and Conclusion

IT holds a prominent place in the 2030 Mauritian vision. As a SIDS with heavy resource constraints, the island has no other choice but to excel in the digital arena to progress to a high-income economy. The additional challenge is for this economic growth to be environmentally sustainable. Marrying IT governance and Green IT in both public and private institutions is thus crucial to meet technological and ecological goals. Nonetheless, analysis of Mauritian legislative and strategic frameworks revealed that directives, guidelines and encouragement for the implementation of IT governance and Green IT measures are not always explicit or IT-specific. For example, Mauritian laws have strong focus on IT security, data protection and risk management, but lack Green IT directives in the Environmental Protection and Energy-Efficiency acts. The National Code of Corporate Governance dictates the adoption of numerous IT governance mechanisms (such as IT steering committees and IT audits), but fails to include Green IT practices, despite its commitment to environmental governance. The National ICT Strategic Plan (2011–2014) recommends the establishment of a National Green ICT Policy, but the latter never progressed beyond its draft phase. Similarly, while the Digital Mauritius 2030 Strategic Plan and Mauritius AI Strategy stress on robust IT governance measures, their reference to Green IT mechanisms remains limited. The same applies for the "Maurice Ile Durable" drive for sustainability and the National Programme on Sustainable Consumption and Production, which conspicuously lack Green IT guidelines. Likewise, though central to the achievement of governance and environmental goals, the Mauritius Roadmap for SDG appears to overlook IT and Green IT governance practices.

More pronounced IT and Green IT directions are therefore required. For example, the National Policy on Green IT would need to be revived and measures put in place to encourage its implementation from IT procurement to IT disposal. This would not only contribute to increased Green IT awareness, but it would also act as an external driver for the establishment of Green IT governance mechanisms within both public and private organisations. In addition, legislative amendments could include mandatory Green IT behaviours. For example, a law requiring Green IT reporting would warrant Green IT practice, monitoring and recording. A section on Green IT governance could also be added to the National Code of Corporate Governance in order to encourage Green IT oversight and board-mandated Green IT audits. Such improvements within the legal and strategic environment would further endorse IT governance and Green IT adoption for a greener, digital Mauritius.

This chapter is limited to existing legal frameworks and government strategies for the promotion of IT governance and Green IT in Mauritius. An analysis of current IT implementations in both public and private organisations would provide a deeper insight into strategic and environmentally friendly IT practices in the island. Future research could also extend the scope of this study to other SIDS for a comparison of best practices and further recommendations for IT-enhanced productivity and environmental sustainability.

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Awareness Factors, Opportunities and Challenges of Iot Application in Australia

Mohammadsajjad Sheikhmiri and Tomayess Issa

Abstract The popularity of implementing new digital technologies like IoT (Internet of Things) is influencing every aspect of business and life; nonetheless the environmental impacts of these new technologies are still not fully understood and investigated. Literature indicates that this urge to look at environmental and social factors in practising business, as well as profit and financial gain, started with the concept of sustainability, where the main goals are to decrease energy consumption and preserve natural resources. This led to theoretical and practical implications such as Triple Bottom Line (TBL) and Corporate Social Responsibility (CSR). These frameworks try to measure and implement sustainable actions in business practices. Advancement in computer science has resulted in new technologies like IoT that have a widespread applicability in several businesses and industries. With this advancement, and its applications in various fields of the economy, the significance of Green technology implementation is more crucial than ever. On the other hand, Australia's economy is suffering from low productivity and efficiency and also has one of the worst performances in regard to the environment and climate change compared to other advanced nations; therefore, IoT technology can offer a variety of solutions to tackle those issues and develop a wide range of industries and businesses, from mining to healthcare. IoT application from an Australian perspective was investigated in this study in terms of awareness factors, opportunities and challenges. In order to do so, a comprehensive survey was designed and conducted in Western Australia in 2019 to study citizens' opinion and knowledge on various topics regarding sustainability and IoT application in Australia. One hundred and five valid questionnaires were returned and based on the outcomes of the survey, which were analysed by SPSS version 25, 2 factors were identified for IoT environmental awareness, 3 factors for opportunities and 3 factors for challenges of IoT application in Australia were also generated. IoT is a relatively new concept and this study aimed to shed light on some important angles of this technology in line with sustainability and Green IT

M. Sheikhmiri (✉) · T. Issa (✉)
School of Management, Curtin University, Perth, Australia
e-mail: hafezmetu@gmail.com

T. Issa
e-mail: Tomayess.Issa@cbs.curtin.edu.au

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initiatives; however, there are still various aspects of IoT that need more investigation and study and some recommendations for government, businesses and academics for future works are suggested, including an emphasis on education and training. The limitations of this study include the survey method and survey population, limited resources and lack of knowledge and awareness regarding the concept of IoT and the research scope.

Keywords Green IT · IoT · Opportunities · Challenges · Australia

1 Introduction

This chapter aims to explore environmental awareness factors and the opportunities and challenges of using IoT technologies in Australia. To address those subjects, the concepts of sustainability, CSR (Corporate Social Responsibility), TBL (Triple Bottom Line) and Green IT must first be discussed to get a more comprehensive depiction of the applications of IoT in this modern world. Secondly, hearing about environmental disasters and climate change alarm cast doubts on the level of environmental awareness among Australians, this calls for an investigation into the aspect of environmental concerns regarding new technologies like IoT. Thirdly, it is important to note that advances in technology have resulted in the rise of an interconnected and digital world, which ultimately discards the need for human involvement; this raises questions about the opportunities and challenges of these technologies. Lastly, the Division for Sustainable Development Goals (DSDG) in the United Nations Department of Economic and Social Affairs (UNDESA) in 2018 issued an index comparing the performance of sustainable development among all the countries around the world, in which Australia ranked 37th in the world. This is behind most of the European countries like France, UK, and Germany and also behind some of the Asian countries such as Japan, Canada, Korea and Singapore (Index 2017). This ranking should be alarming to academics, businesses and the government of Australia as it clearly indicates Australia is well behind the rest of the developed world in sustainable development trends like sustainable cities and communities, CO_2 emissions, renewable energy and research and development expenditure (Jeffrey Sachs et al. 2018). Understanding the need for addressing sustainable development can help these bodies to benefit from new technologies like IoT and also address the environmental and social aspects of sustainability in the following years.

2 Green Information Technology (IT)

Green initiatives to achieve environmental sustainability have become mainstream topics of discussion in the business, consumer, and government sectors (Clarke 1994) and over the last decade, corporations have progressively received internal and external pressure to consider Green IT (Sarkis et al. 2013). Internal pressure comes from employees and shareholders to practice socially and environmentally conscious procedures and external forces are from customers and government who demand more sustainable practices (Weng et al. 2015). It is important to note that although these pressures are effective, the financial gains from adopting Green IT are also lucrative enough to lead companies into these new technologies (Bocken et al. 2014).

2.1 What Is Green IT

According to Schmidt et al. (2009) Green IT is a notion that takes into account ecological concerns and the impacts of Information Technology. Murugesan (2008) endorses the design, manufacturing and managing of IT resources with minimal energy consumption. Eastwood (2009) argues that Green IT is a set of initiatives that reduces the carbon footprint of computing operation, or in brief, Green IT is related to activities that aim to redesign IT into more environmentally friendly systems and reduce the ecological impacts of IT operations (Chetty et al. 2009; Melville 2010).

One of the first examples of applying the concept of Green IT started when the U.S. Environmental Protection Agency started the Energy Star program, where electronic products would be awarded stars for minimizing their consumption of energy and increasing their efficiency. In 1992, this program covered all electronic devices from air conditioners to computers and one of its first benefits was the sleep mode option for computers and standby mode in many other devices (Houde 2012).

One of the important incidents that caused the necessity of applying of Green IT initiatives was the electronic boom throughout the last few decades that resulted in enormous number of electronic devices being used and then discarded as newer models arose, known as e-waste (Heacock et al. 2015). The amount of e-waste produced annually around the world is now around 50 million tonnes, of which 700 thousand tonnes is from Australia (Bedo 2018). This is a dreadful threat to the planet as harmful metals, like mercury and lead, and hazardous elements, like plastics that can harm animals and nature, are contained in e-waste (Heacock et al. 2016).

One scholar argues that apart from e-waste, IT is responsible for about 3% of CO_2 emissions and consumption of IT devices is increasing 12% every year (Jnr and Pa 2015). Another study shows computer devices were responsible for the emission of 830 million tonnes of carbon dioxide in 2010 which is around 3% of all gas emissions and the same number as the aviation industry, the same paper argues the emissions by electronic devices will increase by 6% a year until 2020 (Brooks et al. 2010).

It also needs to be noted that Green IT (Green Information Technology) deals with the effects of energy consumption and waste related to hardware and software computing while Green IS (Green Information Systems) are related to Information Systems that support ecologically sustainable operations (Boudreau et al. 2008). Some researchers believe that these two terms are interchangeable or are even synonymous (Huang 2009; Mithas et al. 2010) while some attempt to separate these concepts (Brooks et al. 2010; Melville 2010).

Murugesan (2008) describes the five phases of Green IT: design, manufacturing, use, disposal and contribution. Green energy use is about dropping the energy consumption of computers and systems. Green design reflects designing energy-efficient computers, servers and cooling equipment. Green disposal suggests recycling of electronic devices. Green manufacturing suggests manufacturing methods that have a minimal footprint on nature. Furthermore, Nanath and Pillai (2012) argue that there are two parts of Green IT, where the first part looks at how to reduce the carbon footprint of IT on nature and the second part is how, with the help of IT, environmental issues of other industries on the planet can be solved, as a result they argue that direct effect, decreasing the ecological impact of IT, and indirect effect, supporting initiatives to endorse sustainability, should be discussed separately. These direct and indirect effects are discussed by Yuri (2008) who argues that a Green IT project by Bank Santander to replace old computers and printers with new models resulted in an over 60% drop in consumption of energy and saved over 400,000 sheets of paper. Speshock (2010) even argues that implementing Green IT initiatives are inevitable for businesses and governments not just because of climate change, customer pressure and legislation but also due to the rapid increase in energy prices. One estimate by the U.S. Environmental Protection Agency forecasts the demand for all energy sources will increase by over 50% over the next 25 years; this can push the prices to record levels which can harm businesses all around the world (GNB 2007). Based on these facts some scholars name economical, ethical and regulatory reasons for implementing Green IT initiatives (Molla 2009; Murugesan 2008; Speshock 2010). According to Bose and Luo (2011) economic reasons are about reducing the cost of operations, ethical reasons are about preserving the environment and regulatory reasons are about complying with the law. According to (Brooks et al. 2012) all the benefits and drivers of Green IT can fall into two categories of environmental and cost benefits, others emphasise business competition, stakeholders and public pressure and sustainable development as the main drivers of Green IT initiatives (Cerny 2008; Varon 2007).

Hedman and Henningsson (2010) argue that three strategies can be used to implement Green IT. The first being storefront strategy, which doesn't require any change to business activity as it aims to review current business activities to see if any can be presented as Green. Secondly, tuning strategy which tries to fit Green IT into the business model, like reducing the number of physical server computers by setting up virtual servers and lastly redesign strategy which changes the structure of processes to get the full benefits of Green IT technologies. On the other hand, (Shapiro 2008) believes in small steps toward Green IT like improving power management, virtualization and recycling programs.

Regardless of the different approaches, more knowledge of Green IT is needed before implementing any strategy. Some Green technologies are as follows.

2.2 Big Data and IoT

Data is growing fast in businesses all around the world and a recent study showed over 30% of businesses are now completely data-driven and over 90% felt there should be more investment in Big Data technology (Partners 2019).

Although the concept of Big Data can be traced back to 1880 where the U.S. Census Bureau used a tabulating machine to process and collect data during the census which saved them ten years of labour and millions of dollars (Foote 2017), it was around 2005 that social media giants like Facebook and YouTube started to face the enormous amount of data that were created by their users daily and they needed new methods to handle this data. In the same year, a framework to store and analyse this "big" data was developed by Hadoop and the buzz word of Big Data started in the IT world (Oracle 2019). An important note is that today not just companies and governments create data but all people in society with electronic devices are responsible for the massive amount of data generated every second around the world (Elragal and Haddara 2014). The International Data Corporation (IDC) predicts that by 2020 the total volume of data will be around 40 thousand exabytes which means over 5,000 gigabytes for every human being on the earth (Gantz and Reinsel 2012). With the arrival of the IoT (Internet of Things) in which millions of new devices are connected to the Internet, organizations like NASA that need the enormous data of the universe to be manageable and the healthcare sector that needs all the data of patients and diseases to be analysed to map or make sense of diseases and treatments, the necessity to have the technology to address all the issues regarding storing, managing and analysing unstructured or structured data was inevitable (Dhindsa et al. 2018; Shannon 2019).

This amount of data, which could be unstructured or semi-structured, needed new methods and techniques for storing and processing; this formed the term Big Data (Ebner et al. 2014). Oracle (2019) defines Big Data as an umbrella term for enormous or multi-layered datasets that normal data-processing methods are inadequate to handle. Intel (2015) characterizes Big Data as big amounts of data that is complex and unstructured. Microsoft defines Big Data as a computing method with the help of machine learning and AI (Artificial Intelligence) to manage complex sets of data (Microsoft 2013) or as De Mauro et al. (2015) suggests data properties categorized by high volume, velocity and variety (see Fig. 1) which needs technology to be transformed into a value. Volume, velocity and variety are the three main characteristics of Big Data, according to numerous data experts, where volume stands for the enormous amount of data, velocity refers to the speed of generating or creating new data in the system (users of Instagram post over 45,000 pictures every minute) and variety means data is not in just one format or kind (movies, documents) and it is unstructured (broken files, missing data) (Furht and Villanustre 2016; Russom 2011; Sharma and Mangat 2015).

Some scholars define more characteristics like vision, verification, validation, value, complexity and immutability to Big Data (Emani et al. 2015; Gandomi and Haider 2015).

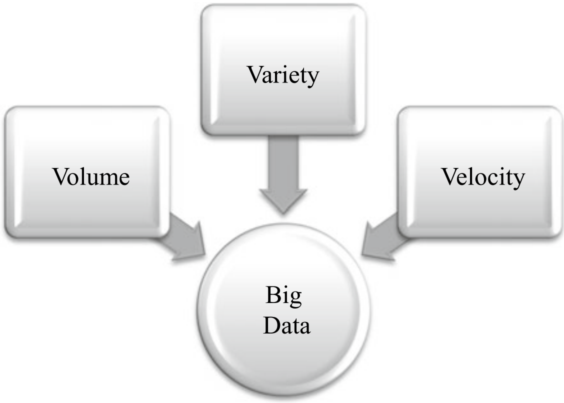


Fig. 1 Main characteristics of big data (prepared by the authors)

There are various Big Data models that address different requirements in terms of storage, processing and analysing but most of them consist of three layers: the infrastructure layer, which is the physical part that consists of servers, storage systems and cloud infrastructure, the software layer that stores, processes and analyses the data and lastly the service layer that consists of all the external services like the security, training and support that are needed for Big Data (Wu et al. 2016).

Furht and Villanustre (2016) demonstrate six steps (see Fig. 2) to show how Big Data works: first, data is collected from different sources, next all this data is loaded into a single storage medium, thirdly, the format and content of the data is determined, fourthly, integration of the data takes place, the fifth step is analysis where analytics and business intelligence take place and finally delivery where real-time querying and visualization for a business purpose occurs.

As explained in the previous section, Big Data enables people to handle large sets of data, some practical applications of this technology is explained in the following: IoT is a significant application of Big Data (Chen et al. 2014). Radio frequency identification (RFID) and sensor network technologies in sectors like agriculture, transportation and healthcare are two of the main sources of data in IoT (Talpur 2013). This large volume of data needed to be examined to identify trends and patterns, find hidden relationships and ultimately create new knowledge, all of which happens in the realm of Big Data (Verma 2018). One good example of the usage of Big Data in IoT is in agriculture where sensors monitor the moisture of crops and

Fig. 2 Big data flow (prepared by the authors based on (Furht and Villanustre 2016))

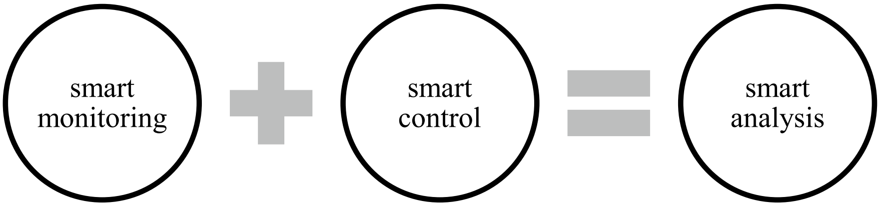


Fig. 3 Big data in IoT (prepared by the authors)

notify the farmers when the crops are ready for harvesting. Smart machinery can even be controlled by IoT technology and feeding data from Big Data technology can help the farmers with planning, harvesting and storing their product (Bronson and Knezevic 2016) (see Fig. 3).

Big Data can transform the healthcare industry by increasing efficiency, forecasting disease epidemics and decreasing healthcare expenditure for everyone from patients to governments (Nambiar et al. 2013). Big Data can be beneficial in collecting data from all different sources (labs and hospitals all around the world) and analyse it to identify patterns and correlations that are hidden to human eyes. Moreover, it allows doctors to see patient's symptoms from all around the world to prescribe the correct prescription and lastly, governments can adopt an improved health system based on the symptoms and disease evolution that relates to their nation (Murdoch and Detsky 2013; Vayena et al. 2015).

Telecommunication data volume is increasing 30% per year and for this reason a survey by "Telecoms Intelligence" shows half of Telecom operators had investments in Big Data (wilmerhale 2018); therefore Telecom giants are one of the biggest investors in Big Data (Buhl et al. 2013, Deloitte 2015). There are various benefits to telecommunication companies coming from Big Data, according to Deloitte (2015) some of these benefits are network infrastructure management, service access integration, marketing and sales. Mehra (2015) argues that the benefits from Big Data in telecommunication are better network security, decreases in fraud, targeted campaigns and adjusted pricing. Lastly, according to Banerjee (2013) the ability to integrate all data sources, the ability to create smart reports, the availability to use analytics capabilities and data consolidation are all benefits of Big Data in telecommunication, these benefits can result in an increase in revenue, customer loyalty, a better customer experience and business flexibility.

Big Data might be a crucial factor in the future of transportation and businesses are using this technology to optimize the routing and efficiency of their drivers (Wang et al. 2016). To give a simple example, a trucking company in the US put over a thousand sensors in each of their trucks to monitor all the information needed to deliver a flawless performance using smart transportation (Rijmenam 2018). Big Data can be beneficial in the following areas of transportation: real-time routing, network planning, capacity planning, address verification and smart marketing (Jessop 2015). Apart from transportation and logistics, Big Data is widely used for traffic surveillance systems, leading to incident prediction, congestion reduction and improved city planning (Shi et al. 2016). The application of Big Data in transportation can also be extended to smart driving, anti-theft and anti-terrorism initiatives and crime fighting (Lohr 2012; Williams et al. 2017).

As discussed previously, Big Data is useful in many industries around the world by offering new solutions, however, there are several challenges to using this technology. The first concern of using Green technologies is the high energy consumption of Big Data storages, Mehdipour et al. (2016) identify data centres where even with Big Data frameworks like Hadoop, Amazon and Google, the energy consumption is very high (about 40% of all IT devices consumption) and more importantly, the greenhouse emissions caused by heating, ventilation, and air conditioning of these data centres are alarming (Harnik et al. 2009). This problem leads to one of the biggest challenges of Big Data which is how to benefit from Big Data while reducing hardware and software requirements (Chen et al. 2014). Related technologies like cloud computing and virtualization are suggested to address these problems (Labrinidis and Jagadish 2012). The other challenge of Big Data is related to NoSQL and the various approaches and techniques which create a doubt about data management in Big Data (Zaki 2014). Another concern regarding Big Data is about ethics and the privacy of data, one controversial example of this could be studying peoples preferences on pornography sites to be used in a behavioural study (Hill 2010). These Big Data stores could be very lucrative marks for hackers or any other interested party with malicious intents, including rival companies or enemy governments (Harvey 2017). Lastly, the complexity of understanding and implementing Big Data makes it a challenging task to find suitable experts for corporations and governments (Sivarajah et al. 2017) (see Fig. 4).

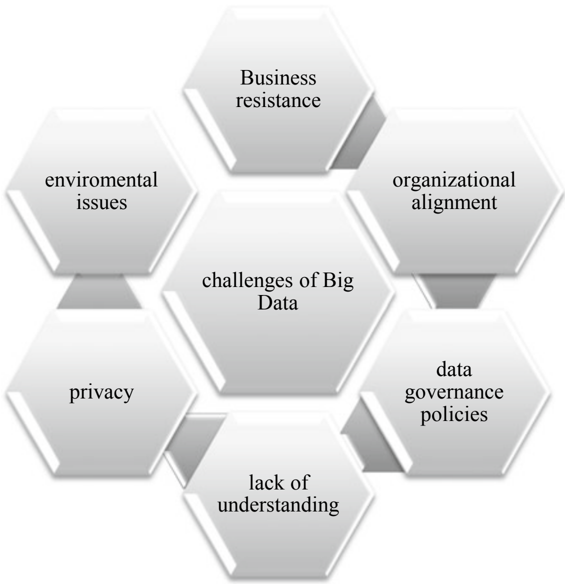


Fig. 4 Challenges of big data (prepared by the authors)

"We need to empower computers with their own means of gathering information, so they can see, hear and smell the world for themselves" (Ashton 2009). These days, IoT is a buzzword in the world: smart cities, smart cars, smart houses, smart devices and a smart world (Tiwari 2017) but its history goes back 20 years to when Kevin Ashton first used the term IoT in his presentation for the linkage of RFID (radio-frequency identification) and supply chain management (Ashton 2009). Like other concepts in technology, there are various definitions for it: Kranenburg (2008) defines it as a global network with a self-organizing capability where devices form an information network, similarly, Ray (2018) defines IoT as a worldwide network with advanced capabilities. Gubbi et al. (2013) argue that from 2011, the amount of interconnected things on the Internet overtook the population of people on the Earth, they estimate that over 50 billion devices (things) will be connected to the Internet by 2020 and these connected things will transform many businesses and function without human interaction. Kang et al. (2015) define IoT as an Internet environment where things like people, data and machines share information, with most of the information being generated by sensors and Big Data tools. Minerva, et al. (2015) focuses on the features of IoT which makes it easier to understand the requirements of IoT: interconnection of things, the Internet, exclusively distinguishable things, ubiquity (anywhere and anytime), sensing capacity (the ability to sense the environment), intelligence, interoperable communication ability, self-configurability and programmability (Fig. 5).

One might ask – "How do businesses and governments want to utilize and benefit from interconnected devices?" (Lianos and Douglas 2000). Ferguson (2002) answers this question by pointing out the need for anticipation and predictability in today's world and Nunberg (2012) argues that interconnected things allow businesses to be more efficient, diminish errors, reduce the loss of theft and manage complex systems. This led to a European commission in 2009 announcing that the integration of the Internet and sensor networks (things) will transform devices into intelligent

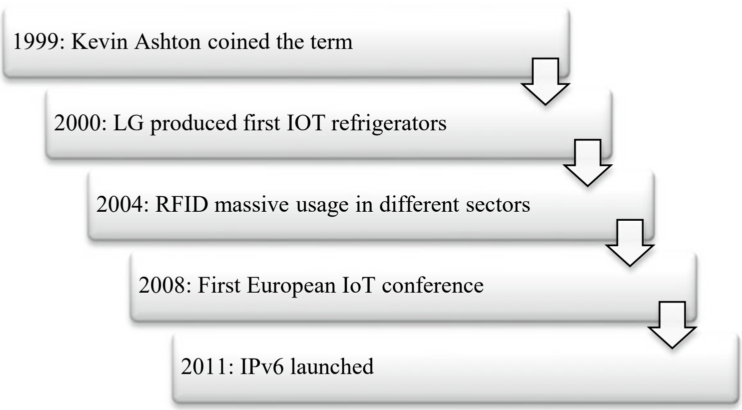


Fig. 5 Milestones of IoT (prepared by the authors)

and aware ones (COMMUNITIES 2009). To illustrate what IoT can simply do, Kang et al. (2015) discuss how a "Freestyle Soda Machine", supplied by Coca-Cola, works: the machine gives 147 taste options to customers, from which the desired mix will be chosen and customers can collect their drink from the nearest vending machine. In this way, Coca-Cola can identify what tastes and flavours are preferred by their customers and these can be reflected in their marketing and sales strategies.

The architecture of IoT is a crucial topic that shows how IoT should be implemented (Ullah et al. 2019) but before determining a suitable architecture, some requirements need to be fulfilled. Farahzadi et al. (2018) argue that three mechanisms are needed: hardware, middleware and presentation. Hardware is comprised of sensors, cameras and communication tools, middleware is storage and computing tools and presentation is visualization and interoperation tools to analyse data and make knowledge. This model was later expanded by Zhang et al. (2012) where the mechanisms were split into six layers: Coding Layer, Perception Layer, Network Layer, Middleware Layer, Application Layer and Business Layer.

Unfortunately, there is no standard model or design for implementing IoT (Madakam et al. 2015) however, the following are two of the models that are suggested by several authors and experts.

Joachim (2019) explains this concept architecture with a comparison to a tree in three sections: first, the "roots" technologies where there are must-have technologies like Bluetooth, 4G and 5G mobile networks and RFID, followed by the second "trunk" tier where enablers (middleware) store and analyse the data and then finally the "leaves" section where this data is turned into valuable information such as smart shopping and smart transportation.

The International Telecommunication Union (ITU) suggests a five-tier architecture for IoT which consists of the Sensing Layer, Access Layer, Network Layer, Middleware Layer and Application Layer, this is quite similar to the OSI model used in computer networking (Gigli and Koo 2011).

IoT was built for RFID technology (Srivastava and Kelly 2005) and although RFID is still an important part there are many other protocols including Bluetooth, ZigBee and WIFI (Trappey et al. 2017) that are used in IoT, this section briefly discusses two of the most important ones.

Radio Frequency Identification (RFID) is a platform that transmits data using radio waves with a method of serial numbers (Sun 2012). RFID first appeared in World War 2, where it was used to identify friendly planes, and it has a range of radio frequencies from 100 kHz to 10 GHz. It consists of three main components: RFID tags, readers and an application system (Handbook 2010). When a microchip is tagged, it sends data to an antenna (reader) that communicates between the tag and middleware. RFID is used in numerous industries, for instance, in a car manufacturing business, RFID can be used as anti-theft immobilizer or in inventory management (Jia et al. 2012).

One of the newest technologies that may have a major impact on IoT in the following years is the Fifth Generation (5G) wireless network technology (Mavromoustakis et al. 2016). 5G can support Internet connections at least 40 times faster than 4G, 5G technology uses a new radio spectrum (mmWave) capable of transferring enormous amounts of data over short distances with very high speed (West 2016). The ability to transfer gigantic data volumes, the capability for remote sensors to capture data and pass it to data centres, and real-time analysis which can lead to improved AI and machine-learning are some of the potential benefits of 5G for IoT (Sequeira 2019). For instance, smart home devices and driverless cars can be more reliable and more efficient due to the fast speed of 5G (Diss 2018).

There are several application areas influenced by the developing Internet of Things, these can be categorised by network accessibility, scalability, coverage, human involvement, repeatability and impact (Gluhak et al. 2011), on the other hand Lee and Lee (2015) categorises IoT applications based on Big Data and business analytics, sharing of information and monitoring and control criteria. Chen et al. (2014) name the nine fields of IoT applications as: smart homes, smart medical care, smart safety, smart environmental protection, smart grids, intelligent transportation, smart logistics, smart agriculture, and industry applications. In this paper three of these applications are briefly discussed.

Recent advancements in IoT have enabled cost-effective solutions for houses which can be defined as “Smart Homes”. A Smart Home is explained as a network of interconnected electrical appliances and services where the functionality of these devices can be accessed, controlled and monitored over the network (Jie et al. 2013). For example, by controlling equipment like refrigerators, washing machines or air conditioners, better energy management is achievable. Apart from energy management, with features like online shopping, inventory management and error detection, it can make life easier for consumers (Midrack 2019). It is clear that smart home systems are still in their first phases of implementation and need more research efforts (Santoso and Vun 2015).

In 2010, Google presented the first driverless car to the world and although there is still a long way to go before this technology is commonplace, all of the automobile industry giants are working on it (GRAVELINE 2015). The features of smart cars are not just limited to self-driving cars but also include advanced route management, petrol and engine management, smart parking, traffic controls and better safety for pedestrians. One example of the benefits of smart cars: 30% of road traffic can be attributed to drivers looking for a parking space, this can be eliminated by IoT as interconnected devices can spot free parking spaces and even form a virtual queue. The number of cars with IoT technology is expected to reach over 150 million by 2020 (Press 2014).

The concept of “Industrial Internet” was first introduced by General Electric (Leber 2012), and is defined as the two mechanisms of machine sensors and the Internet working together to create value. In simple words, the Industrial Internet is a network of industrial machines that with help of the Internet can be managed and be functional (Dorsemaine et al. 2015). Due to its distinctive aim to collect and analyse information without human interaction and to be able to work and sync with other devices (Boyes et al. 2018), it distinguishes itself from the normal IoT. The Industrial Internet is still in the development phase and large corporations like IBM, Siemens, Honeywell and GE are just starting to invest in it. For instance, Honeywell recently introduced its Industrial Internet of Analytics platform named Honeywell Forge, this first phase will be used in buildings to manage building systems (Dignan 2019).

When the term IoT was coined at the end of the last millennia, practical implementation of this technology was not anticipated to be in the near future (Gubbi et al. 2013), however, the consumer market saw one of the first attempts at IoT application when LG produced a smart refrigerator that had Internet connectivity and was able to order groceries online (Wolf 2017). This "human, machine" system eventually led to concerns about the environmental factors of IoT (Liu et al. 2017). Factors like the reduction of energy consumption, benefiting from renewable energy sources and using recyclable materials are some of the key expectations of people and businesses from IoT (Al-Ali 2016; Shah et al. 2019; Springwise 2018). Similarly, portability efficiency of IoT where a wide range of sensors and devices can be functioning together to form a network of connected devices is discussed as one of the environmental factors as it might mitigate the need for unnecessary commuting and consumption of resources (Nikoletseas et al. 2014). However, issues like challenging upgrades and support due to the complexity of IoT systems and architecture are decisive factors that might harm the environment (Gardiner 2014).

The Internet of Things is a relatively new concept that is still being thoroughly investigated (Bindi 2016), therefore awareness factors with dedicated information and literature that targeted Australia were not available at the time of conducting this research.

There are numerous opportunities presented by IoT applications (Elmustafa and Zeinab 2017), some of these opportunities include.

With the current growth of IoT and the associated increase of IoT devices, a significant amount of energy is being consumed. It is predicted that by 2025, IoT devices will consume 46 TWh electricity, roughly equal to the annual consumption of the country Portugal (Martin 2016). This is an opportunity to address energy consumption of IoT devices: Albreem et al. (2017) propose some solutions like mandatory idle and sleep mode for sensors and all other IoT devices, consuming renewable energy, optimization techniques and using modified algorithms to decrease data size. On the other hand, Martin (2016) suggests new laws are needed to set maximum power consumptions for each device which can result in more efficient devices and weed out non-compliant devices. Similarly, Liu and Ansari (2019) suggest self-powered devices with ambient energy harvesting and double battery architectures (hybrid systems) as Green solutions. While there are numerous researches and solutions already available, Green IoT is still in its early stages and some technical and legal concerns need to be resolved, including reliability and mandatory Green initiatives. Meanwhile, raising Green IoT awareness among consumers and the people who are using smart devices can accelerate the progress of implementing Green solutions for IoT devices and technology (Liu and Ansari 2019; Petrut and Otesteanu 2018). Some of the areas that Green solutions can benefit IoT are shown in Fig. 6.

One of the most beneficial aspects of implementing IoT technology is the improved productivity and efficiency in various businesses and industries (Bamigboye and Ademola 2016). According to Jurvansuu (2013), IoT improves

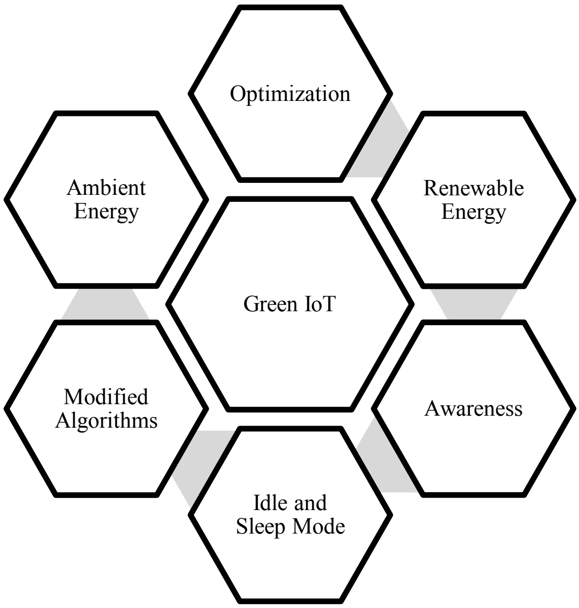


Fig. 6 How Green solutions Benefit IoT (prepared by the authors)

productivity by helping make the decision-making process faster and more accurate, facilitating real-time control management, process optimisation, creating higher efficiency in operational procedures, conserving resources, implementing remote control capability and improved business models. To give an example, smart transportation can improve productivity by consuming less energy, decreasing traffic and emissions, making movement faster and giving more accurate movement information which all result in a more efficient use of time and energy (Saarika et al. 2017). Another example of improved productivity and efficiency in implementing IoT technology is in the electricity sector where Smart Automatic Meter Reading (AMR) eliminated the need for a person to visit each site in order to gather consumption data, this lead to reduced costs, errors and time (Ali et al. 2017).

One of the opportunities presented by IoT is that businesses can increase their reputation which can lead to an improved marketing strategy, higher revenue, a talented pool of job candidates for vacant positions and increased transparency (Abashidze and Dąbrowski 2016; Ashwini 2017; Đurđević et al. 2017). Apart from that, implementing IoT solutions can help business to abide by new laws and regulations passed by the government (Daube 2019). The important note regarding this topic is that unlike many developed countries, like the USA and UK, Australia still does not have common and specific laws about IoT application. In the United States, there are several laws like the IoT Consumer TIPS Act and SMART IoT Act which specifically address privacy and security of IoT applications. Australia, however, still relies on old legislation like the Telco Act and Privacy Act which were passed over 20 years ago; these acts cannot address cybersecurity and privacy concerns on the complex scale of IoT and Big Data (Commissioner, 2016). The Privacy Act was updated in

2012 with some policies addressing privacy and the security of personal information over the Internet but according to Caron et al. (2016) these efforts are still not comprehensive and therefore a dedicated Act seems necessary.

IoT offers new opportunities to businesses and the community, some of these applications were discussed in the previous section, but there are still some major challenges and risks in need of precise solutions. These challenges starts with the lack of a unified framework and standards to protect privacy and security concerns (Van Kranenburg and Bassi 2012).

As mentioned in the architecture section, IoT does not have a standard and unified architecture or framework and when considering the many different technologies and protocols that need to be integrated within the concept of IoT, it is evident that finding a sole architecture or framework for IoT is a very complex and challenging issue (Al-Qaseemi et al. 2016). Shaikh et al. (2015) argue that with a massive number of interacting things, with different protocols, communication patterns and technologies in which the number of things is increasing every second, the scalability and interoperability needed for a unified platform is not yet available. All these issues result in the complexity of IoT, which, according to Upadhyay (2017), means different platforms with no all-rounded solution and no-integrated data. This complexity becomes even more complicated when considering large models like a smart city or the various components needed to co-operate within health systems (Hernandez-Bravo and Carretero 2014). The solution is to develop a secure framework that covers all the layers from sensors and middleware to M2M (Machine to Machine) and Internet standards regardless of manufacturer or operators of devices (Gupta and Quamara 2018).

IoT is comprised of a hefty number of interconnected things, therefore, new social and ethical requirements to address privacy, data security and other related subjects are needed (Popescul and Georgescu 2013). A survey by Ann Bosche et al. (2018) showed that almost 50% of consumers are concerned with the security of IoT and a report from the European Commission indicates some of the features of IoT that can be a source for ethical problems: ubiquity, invisibility, identification, ultra-connectivity, autonomous behaviour and merged intelligence (Hoven 2013). Furthermore, IoT devices have become golden targets for hackers looking to take advantage of the flaws and vulnerabilities of this new technology, for instance, in 2017, hackers directed 5000 IoT devices of a University to attack the University‘s network in order to switch the network off (Shaw 2017). Therefore Valacich and Schneider (2017) argue that in order to address ethics in IoT, the following points need to be considered: property right of information, integrity of information, the right of privacy and the right of access. These points can be the basis to address most of the issues in privacy and security in IoT.

IoT is likely to continue growing and businesses need to adapt to this technology that requires a high IT skillset. A recent survey showed that over 80% of organizations were working on a IoT solution but only 20% were able to fully implement the solution (Inmarsat 2018), according to the same survey, one of the biggest obstacles to IoT adaptation is the lack of required skillsets, particularly in the mining and agriculture industries. It seems businesses misjudged the complexity of IoT projects and the need for highly skilled professionals to implement these projects. Weiss (2017) reports, in the near future, the shortage of skilled experts in IoT will become a challenge to IoT adoption and progress.

IoT is capable of driving various areas of business and aspects of human lives from constructors and designers of the technology to the people (from individual consumers to students and researchers). The Organisation for Economic Co-operation and Development (OECD) predicts IoT might soon be commonplace in daily-life, with billions of interconnected things around the world (OECD 2017) and investment in IoT is forecasted to reach $745 billion in 2019, a 16% jump from the $646 billion spent in 2018 around the world (Lund et al. 2014). Australia‘s share, according to the ACS (Australian Computer Society), may reach $308 billion in GDP over the next 10 years (Shanahan 2018). It is claimed that IoT can help Australia's economy to benefit from a steady growth in the following years, particularly in sectors like agriculture, mining and construction (PwC 2018). In agriculture, for example, by implementing an IoT technology named "Pest Detect-and-Deter (VPDaD)", farmers can successfully decrease the amount of crops eaten by pests, which can ultimately save up to AU$1 billion annually (Kwan 2019). Another example is the winner of Best IoT Product in 2018, awarded by the IoT Festival in Melbourne, Reekoh IoT fabric, IoT data and API Management Platform for presenting a platform that helps businesses manage their connected devices and analyse and integrate data, to benefit from some of the capabilities of IoT (Writers 2018). As stated before, Internet of Things technologies have been estimated to have a profound impact on business and Australia is on the path of adopting some of these technologies which will have the benefit of boosting the quality of life and competitiveness in businesses in Australia in the near future (see Fig. 7).

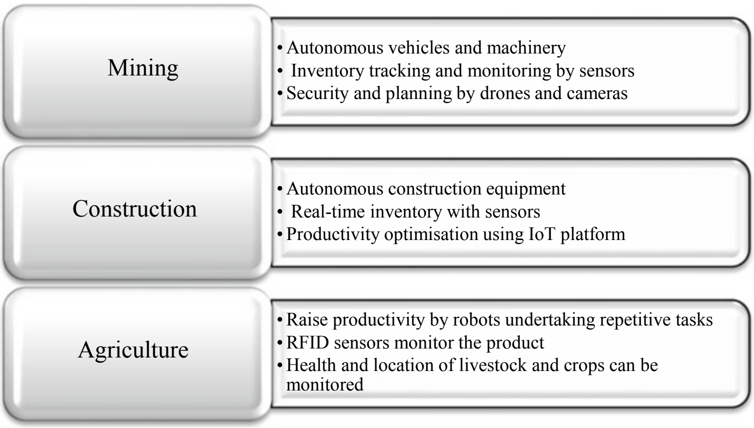


Fig. 7 IoT applications in Australia (prepared by the author)

3 Study Research Questions and Objectives

The motives, reasons and significance of choosing the topics have been explained in the previous section. Research questions and clear objectives to investigate the perceptions and knowledge of Australians in regard to the environmental awareness factors of IoT application and benefits and challenges of the application of IoT were chosen.

The research questions of this chapter are: (1) What are the environmental awareness factors of IoT application in Australia? And (2) What are the opportunities and challenges of IoT usage in Australia?

Furthermore, the objectives of this study are: (1) To assess the environmental awareness factors of IoT application in Australia. And (2) To identify the opportunities and challenges of IoT usage in Australia. As mentioned above, the primary aim of these research questions and objectives is to gain new knowledge about IoT awareness and application in Australia in line with Green IT procedures.

4 Research Method

Survey research, according to Kerlinger (1986), is a study on people by choosing samples from a specific population and determining their connections, relationships and interrelations. Furthermore, Kraemer (1991) recognised three key features for survey research; the survey should statistically examine a particular aspect of its given population with different variables, the survey will be a subjective study because the data is collected from a group of people, and although a survey collects data from a relatively small group of people it can later be generalised to the whole population. Survey research stereotypically uses web-based tools, face-to-face interviews, and online or phone-based interviews using questionnaires. The chosen research method for this study is a combination of quantitative and qualitative methods; to measure and examine the primary data, the quantitative method was used. The data was collected via traditional and online surveys. The qualitative research method was also applied to study the data collected through websites and journal articles, books and applicable sources in current literature.

Survey research has several benefits; according to McIntyre (2011) surveys are good tools to gain information from samples of society and are also well-suited for demographic data to relate and report the structure of the sample. He also notes that surveys are especially beneficial in gathering data about matters that are difficult to measure with other techniques. Moreover, Bell (2013) argues that a broad range of types and variables can be studied with surveys without requiring a large investment and easy methods for generalizing. Similarly, Pfleeger and Kitchenham (2001) state that surveys are cheap, time-saving and accurate in regard to the collected data.

On the other hand, there are some issues with survey research; Fink (2015) notes that surveys can only estimate for the whole population and are not exact and definite measurements. Additionally, surveys are not befitting in investigating phenomena with historical context (Pinsonneault and Kraemer 1993); unintended biases may also happen when conducting a survey as the respondents may answer inaccurately, intentionally answer incorrectly to conceal inappropriate beliefs or refuse to answer entirely. Some respondents may even have difficulty assessing their beliefs or have no ability to recall a certain incident to address the questions (Bell 2013). Some scholars claim that survey research can provide a general picture but with no depth and context (Couper 2011b; De Leeuw 2005).

In the last three decades, with the introduction of the Internet, web-based surveys have had a profound impact on the survey world. According to Couper (2011a) there are eight types of web-based survey: polls for entertainment that have no restrictions or criteria about the participants of the survey, self-selected models where participants receive open invitations on some websites, volunteers who subscribe to websites that participate in all sorts of surveys, intercept models where participants are randomly chosen from visitors to specific websites, list-based models where samples are chosen from a specific list of samples, mixed-mode models where samples are chosen by traditional methods but the survey is conducted through the Internet, a sample group can be selected through the Internet by identifying specific measures and characteristics and lastly, a sample group is selected through the Internet and combined with people without access to the Internet to form a mixed sample group (see Fig. 8).

According to Couper, intercept surveys are the most common these days, where Internet users are asked to participate in a survey from time to time. Nevertheless, more recently social media has become an attractive platform for conducting web-based surveys and it seems it will be the future of the survey (Couper 2011b; Poynter 2010).

There are several benefits to conducting web-based surveys, firstly, web-based surveys are open to innovative and creative types of questionnaires, for example audio

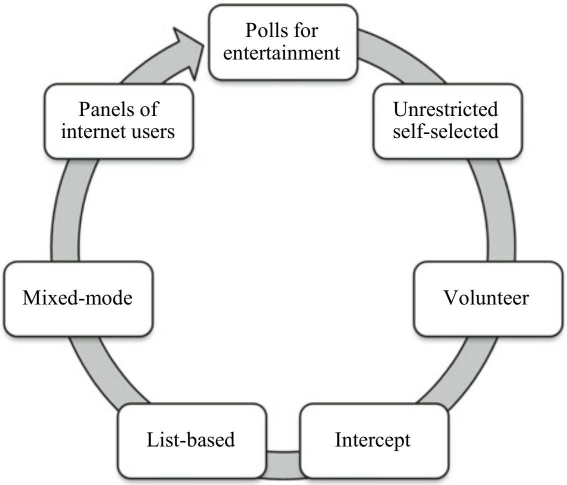


Fig. 8 Types of web-based survey (prepared by the author based on (Couper, 2011a)

or graphical tools can be used to help respondents by providing further information about questions or user-friendly interfaces featuring colourful, attractive design can make the questionnaire more appealing to the participants (Fleming and Bowden 2009). Several scholars argue that this type of survey reduces the survey production costs including printing, posting and labour, reduces the cost of analysing the collected data, diminishes human error and allows broader options to reach the desired sample (geographical or demographical for example) (Bertot and McClure 1996; Smith and Leigh 1997; Zhang 2000). Similarly, Madge (2006) argues that with an Internet based survey, data can continuously be collected without any limitations. Lastly, with the growth of the Internet and consequently email, websites and social media, it seems this platform is more suitable to reach samples with the desired characteristics (Fleming and Bowden 2009).

On the other hand, there are some disadvantages using web-based surveys. According to some scholars, the biggest problem seems to be bias due to the people that have been sampled all having access to the Internet (Crawford et al. 2001; Kaye and Johnson 1999). Additionally, it is evident that there is a vast gap in Internet access among different ethnic and socio-economic groups around the world (Selwyn and Robson 1998). Moreover, several researchers argue that this type of survey can generate incorrect outcomes as some respondents can submit several questionnaires, leave questions empty or answers incomplete (Best et al. 2001; Zhang 2000). Other scholars refer to the low response rate from web-based surveys compared to other methods and argue that the complexity of surveys or personal or controversial questions might be the cause of this statistic (Cook et al. 2000; Crawford et al. 2001). Furthermore, survey fraud is another disadvantage of Internet-based surveys as many people are getting to paid to do surveys and they are not truly interested in honest and truthful answers (Phua et al. 2010).

Traditional survey methods are conducted using several techniques including in-person, telephone and paper-mailed (Goodman et al. 2013). Although these methods are no longer popular, it should be noted that they still have some benefits (Mutepfa and Tapera 2018). Szolnoki and Hoffmann (2013) note that researchers should choose between a web or traditional survey based on the research topic, timeframe and budget. The type of question and data resources should also be taken into account when choosing the right approach (Brandt 2012).

Traditional surveys are described as clearly organized, flexible and adjustable (Mutepfa and Tapera 2019); for example, in using interview techniques, the researcher can change the questions to measure accurate attitudes. Another advantage of traditional surveys is that participants are present and environmental factors can also be considered. All these tools help researchers to employ better control on the sample and the problems faced with web-based surveys such as incomplete answers or data reliability are decreased (M H J van Gelder et al. 2010).

On the other hand, Mutepfa and Tapera (2019) note that it is not always easy and practical to get people to do an interview or even a paper-based survey, they mention examples of researchers trying to do in-person surveys and facing occasional negative reactions from potential participants. Ethical issues are another concern regarding traditional surveys; several scholars note that sensitive or private questions can result in incorrect outcomes as many people do not feel comfortable answering these types of questions (Callegaro et al. 2015; Tourangeau and Yan 2007).

Survey design consists of two phases; firstly, a sampling plan is needed where the procedures of choosing the sample is determined, these procedures involve the sample size and platform to conduct the survey; secondly, estimation of the validity and reliability of the outcome is established including the desired response rate and accuracy of data (Levy and Lemeshow 2013). Participants must be able to identify the variables of the survey and any limitation of resources needs to be addressed. By including a comments section in the survey participants can also provide information that was not considered in the available survey answers. The survey design used in this dissertation contains an online questionnaire created by the Qualtrics survey website (https://www.qualtrics.com/au/). The tools on this survey website enabled the survey to be created and distributed, and enabled the monitoring of the data gathering process in real time. Alongside the online questionnaire, traditional techniques were also used in collecting the data.

Unit of analysis is a core part of the subject of the study, some of the known examples are countries, states, companies, individuals and industries (Patel 2009); Säljö (2009) argues that the unit of analysis is the specific unit or component that is being investigated. While it is crucial to determine the sample size of the desired unit of analysis, it is also beneficial to have a specific sample, like a workgroup or students in a class, so the responses follow a logical pattern (Attewell and Rule 1991). In this study, the unit of analysis is individuals living in Australia and therefore the focus of this study is about gaining knowledge about the population of Australia. Also, Likert scales were used to get answers on statements made by the researcher. Likert scales are a common measurement technique to scale answers from strongly disagree to strongly agree (Harpe 2015). Using this scale, the participants of a survey can express their opinion in an easy and understandable manner. It is also beneficial for the researcher as the answers are measurable.

Target population and target sample depend on population size, the medium and the budget (Fink 2015), and it is crucial to emphasise that the sample must be selected randomly and without any bias; and define the target population as clearly as possible (Salant et al. 1994). The target population for this dissertation survey was people who live or study in Australia. The majority of respondents are young Australians studying or working at Curtin University in Western Australia. As both traditional and web-based methods of collecting data were used in this research, the target sample was distributed randomly amongst female and males and while conducting the traditional survey, the need to choose participants without bias was taken into consideration. Data collection is referred to as collecting appropriate data with the least possible errors or falsehoods so credible analysis can be performed using the collected data (Sapsford and Jupp 1996). As mentioned before, both web-based and traditional methods were used in collecting the required data. The reason for choosing both methods was that the collected data would be more accurate and reliable. The first step was to share the link for the survey among people using Curtin University email addresses and other social media platforms like Facebook, WhatsApp and Google+. The in-person method was then used to collect data from

Table 1 Quantitative method and qualitative method (prepared by the authors)

	Quantitative method	Qualitative method
Standards	There are various standards and techniques	Techniques and methods are not standardised
Timing	Data collection directs data analysis	Data analysis directs data collection
Format	Numerical	Words
Research methodology	Conclusive	Exploratory
Sample size	Can be medium to large	Usually small
Analysis	Statistical	Usually ratios and counts

random students at Curtin University's main campus and random people in the CBD of Perth, Western Australia. Data analysis is the method used to make sense of the collected data; therefore, patterns, structure or meaning in the data can be identified (Marshall and Rossman 2014). Furthermore, qualitative and quantitative approaches can be used to analyse the data, when using the qualitative approach there is an indivisible connection between the data collection and the data analysis to come to an understanding of the outcome (Gibbs 2002). In other words, qualitative analysis uses descriptive tools to interpret the data, these tools are content analysis, thematic analysis, discourse analysis and grounded theory (Braun and Clarke 2006). Alternatively, the quantitative method explains phenomena using a numerical approach. Measures in the quantitative approach are generally categorised as rational, interval, ordinal and nominal (Seaman 1995). To choose an appropriate method for analysing the data, it is important to identify the differences between the two approaches, depicted in Table 1.

Overall, the purpose of collecting data is to create new knowledge about a phenomenon and regardless of which method is implemented, the data needs to be transformed into meaningful and reliable discoveries (Thorn 2000). For this dissertation, as stated before, both quantitative and qualitative methods were used, as the Likert scale is a quantitative tool to measure qualitative variables and the software used (SPSS) is a powerful quantitative tool to analyse the collected data. Statistical Package for the Social Sciences (SPSS) is a statistical and text analysis tool that can perform various complex tests and analytics. The advantages of using this software are ease of use, ability to analyse and manage complex and large sets of data, flexible data input and output, an extensive variety of displays, approaches and diagrams and data validation. Version 25 of this software was used in the data analysis for the dissertation. Data from both quantitative and qualitative approaches were necessary to gain new knowledge about the collected data. One of the most important characteristics of a study is the quality of the survey or in other words the validity and reliability of the survey. Gall et al. (1996) argue that the consistency of a survey, reaching the same outcome for repeated tests, is called reliability. Similarly, the validity of a survey is associated with the variables that were correctly measured or in other words, the collected data is relevant to the research questions. Creswell

(2009) notes that authenticity, truthfulness and accuracy are the main pillars of the reliability and validity of research. Similarly, having biased data or unethical modes of data collection can have massive negative effects on the validity and reliability of the collected data. Low response rates and missing or inaccurate questionnaires can also affect the reliability and validity of the survey (O Nyumba et al. 2018). To ensure the reliability and validity of the survey is satisfactory, the researcher used several techniques and tools. Firstly, the questionnaire was designed carefully to address the research questions and all the questions in the survey to be related to those objectives. Secondly, during the data collection phase, the researchers made sure participants were aware of the topics and the concepts behind the survey; and lastly the reliability and validity of the survey was tested using SPSS software to ensure that the results are reliable and accurate.

5 Evaluate the Survey Results

A total number of 121 questionnaires were distributed amongst Australians via the Internet and face-to-face interactions, however only 105 were valid as the other sixteen questionnaires had some areas left blank by respondents. This is shown in Table 2.

As shown in Fig. 9 the distribution of gender of respondents is almost equal as 52% of participants are female and 48% are male.

Table 2 Survey results (prepared by the author)

Survey results	
Questionnaires returned	121
Valid returned	105
Response rate	87%

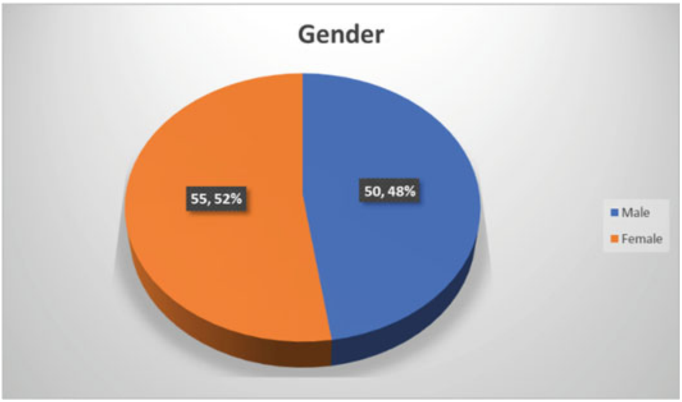


Fig. 9 Gender distribution (prepared by the author)

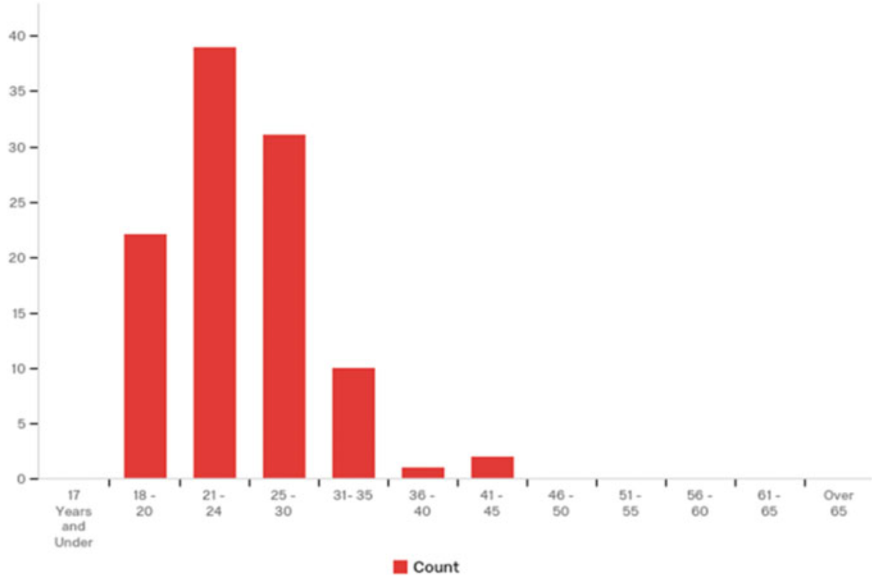


Fig. 10 Age distribution (prepared by the author)

Figure 10 illustrates the age distribution of the participants; it shows the majority of the participants are aged between 21 and 24, followed by aged between 25 and 30 and 18 to 20 years old. No-one under the age of 18 or over the age of 46 participated in this survey. The reason for this is that the participants were mostly university students.

As shown in Fig. 11, the level of education among respondents was very high as more than 80% have at least a Bachelor degree. The education status statistic shows 43 respondents (41%) with a Bachelor degree, followed by 37 respondents (35%) with a Masters degree, 3 participants with PhD degree and the rest with professional certificates or various diplomas. The lowest level of education among participants was high school graduate with a professional certificate.

As seen in Fig. 12, the highest number of respondents, 17 (16%), had Science and Engineering degrees followed closely by Management (14), then Information Systems and Health Science both with 13 participants. People with a background in Computer Science, Business Law, Art and Design and Economics and Finance had the smallest contribution to this survey.

Figure 13 depicts how the participants connect to the Internet. Over 93% of respondents stated that a smartphone is one of their main devices to connect to the Internet; followed closely by a laptop (88%) and tablet (61%), the least popular devices to connect to the Internet were PDAs, netbooks and workstations with less than 5% of participants using any of these devices to connect to the digital world. The important

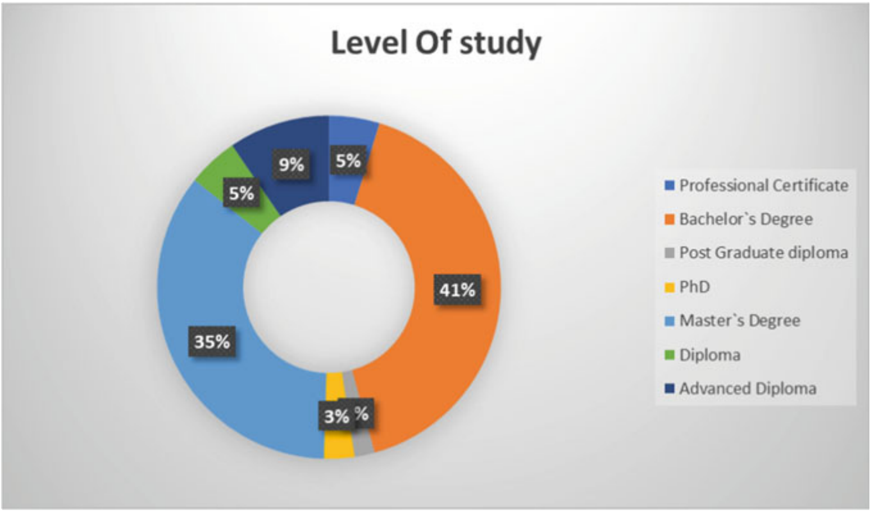


Fig. 11 Level of study (prepared by the author)

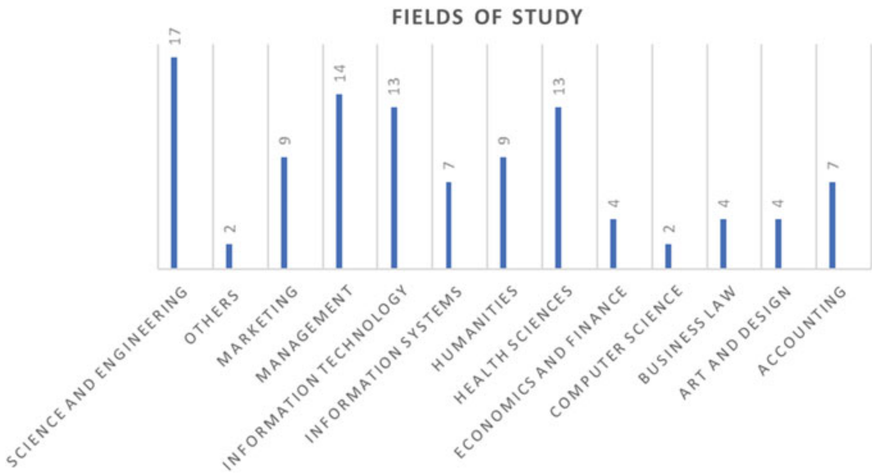


Fig. 12 Fields of study (prepared by the author)

note for observing Fig. 27 is that the green line represents the number of participants who use that specific device, the blue line represents the percentage of users based on number of respondents (105) and the yellow line represents the percentage of total choices (305).

Figure 14 indicates how the participants answered the question "Do you think changing devices frequently will cause damage to our planet?". The majority of the respondents (67%) believed that frequently changing electronic devices harms

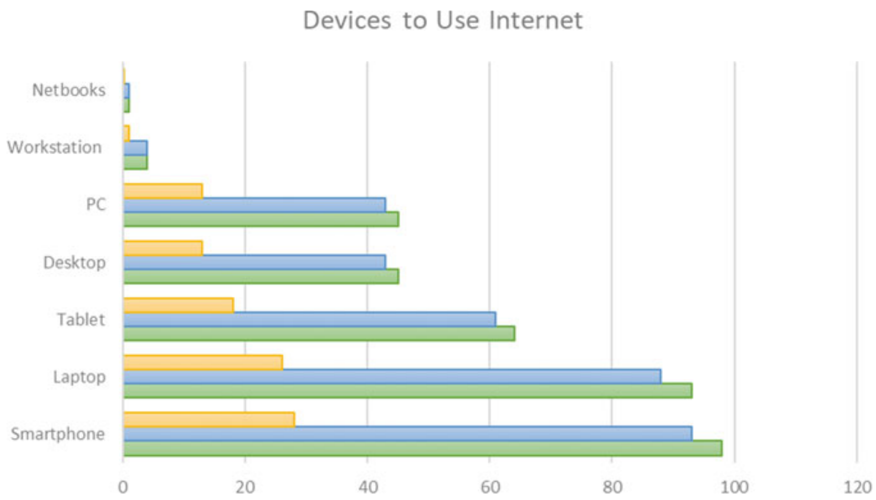
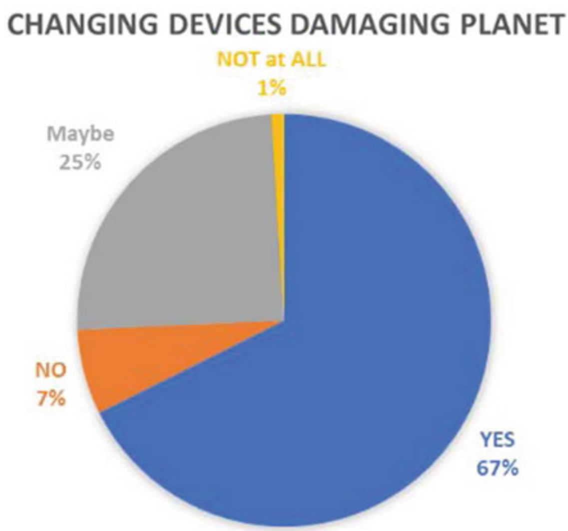


Fig. 13 Devices used to connect to the INTERNET (prepared by the author)

Fig. 14 Does frequently changing devices damage the planet?



the planet and only 7% thought there is no harm to the environment in frequently changing devices. Only one participant believed that frequently changing devices has absolutely no impact on the environment. On the other hand, almost 25% (26 participants) were not sure about a definite answer and chose the "Maybe" option.

Figure 15 demonstrates how the participants were first introduced to the concept of sustainability. Participants were permitted to pick more than one choice for this question. A vast majority (61%) of participants were first introduced to the concept

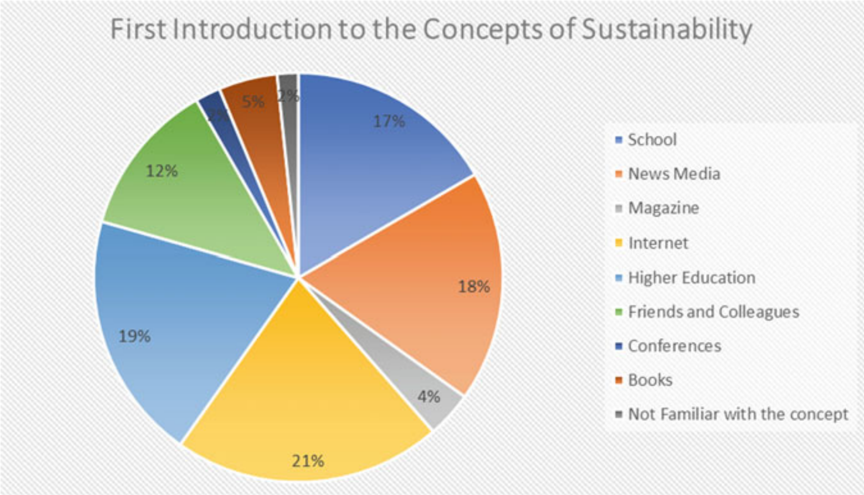


Fig. 15 First introduction to the concept of sustainability

via the Internet, followed closely by higher education (56%) and news (52%). On the other hand, five participants were not familiar with sustainability concepts and Green Information Technology (less than 5%).

Figure 16 depicts participants' opinions regarding the best method to change the attitude and behaviour of people about sustainability and Green Information

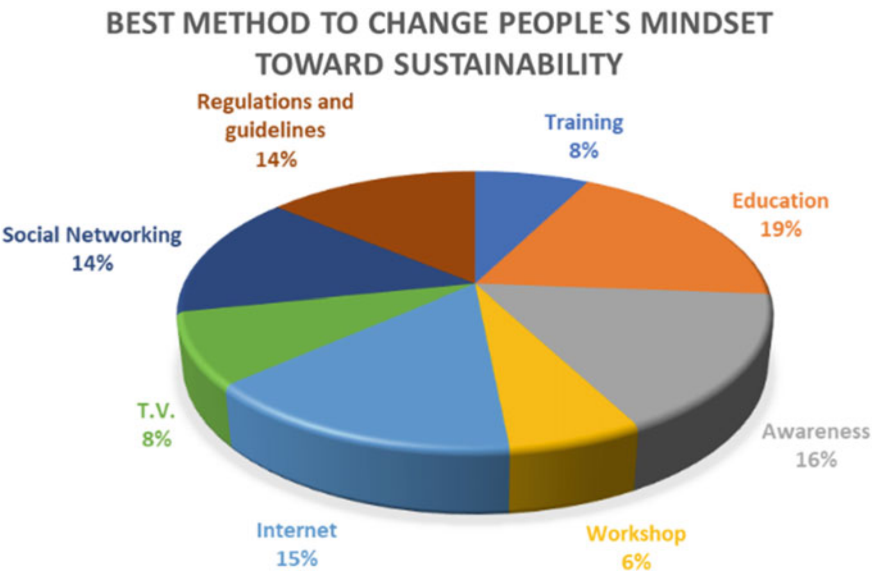


Fig. 16 Best method to change people's mindset toward sustainability

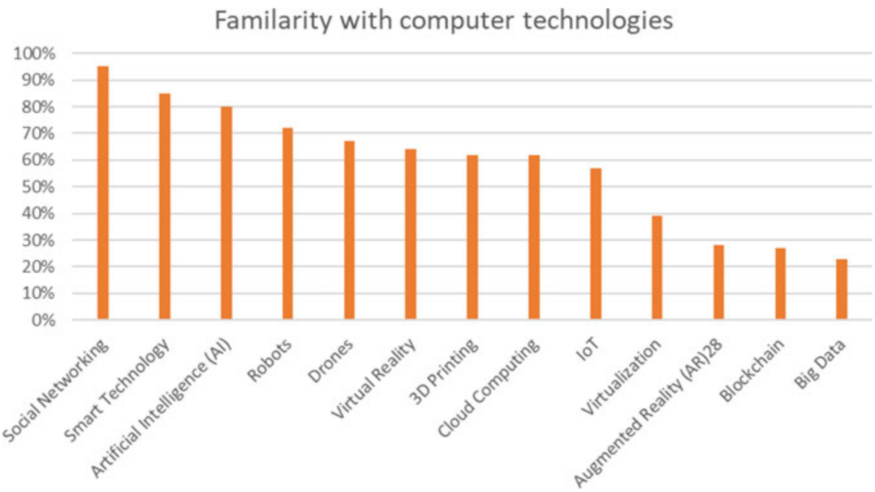


Fig. 17 Familiarity with computer technologies

Technology. Again, participants were allowed to pick more than one choice for this question; over 80% of respondents believed that education is the best method to change people‘s mindset about sustainability and Green IT, followed narrowly by awareness (69%), Internet (65%), social networks (62%) and regulations and laws (60%). On the other side, they didn’t think training (32%), workshops (27%) or TV (36%) could mitigate the issue.

Figure 17 demonstrates the familiarity of different computer technologies of the respondents. Almost all the participants were familiar with social networking (95%) followed by smart technology (85%), Artificial Intelligence (80%) and robots (72%). On the contrary, technologies like Augmented Reality (AR) (28%), blockchain (27%) and Big Data (23%) were not as well known to the participants.

Lastly, in terms of the actual application of those computer technologies, Fig. 18 shows that once again social networking is the computer technology most used by the respondents (93%), followed by smart technology (64%), cloud computing (49%) and the Internet of Things (IoT) (21%). Technologies like Augmented Reality (AR) (0%), robots (4%), blockchain (7%) and Big Data (9%) were the least used by participants of the survey.

5.1 Cronbach’s Alpha, Kaiser-Meyer-Olkin and Bartlett’s Test

As stated before, reliability is a vital aspect of any research and there are various tools and techniques to validate and check the reliability of the collected data. One of the methods, developed by Lee Cronbach, named Cronbach‘s Alpha measure is

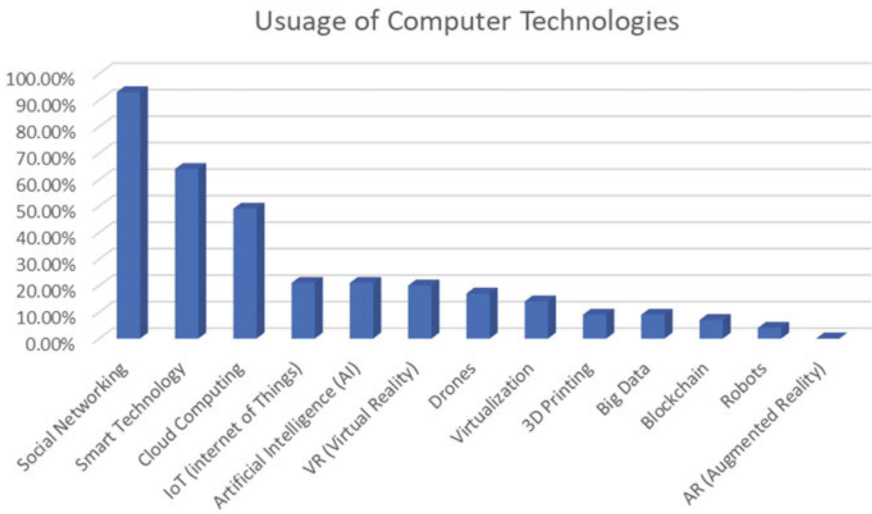


Fig. 18 Application of computer technologies

used to show the internal consistency of a test; the measure is a number between 0 and 1 and the most desirable result is between 0.75 and 0.95. There are several possible reasons for a low Cronbach's Alpha result, which include a small number of questions, missing data and a weak relationship between items (Bland and Altman 1997; Nunnally et al. 1967) (see Table 3).

There were 105 valid cases returned for all three aspects of the survey (IoT awareness, Opportunities of IoT application and Challenges of IoT application) (see Table 4).

Table 5 demonstrates Cronbach's Alpha for the three objectives of the dissertation.

Cronbach's Alpha for "IoT Awareness Factors in Australia" and "Opportunities of IoT application in Australia" is above. 90 which is regarded as excellent reliability and Cronbach's Alpha for "Challenges of IoT application in Australia" is above 0.80 which is regarded as good reliability; possible reasons for the lower alpha in

Table 3 Cronbach's Alpha (prepared by the author)

Cronbach`s Alpha	Interpretation
>90	Excellent
>80	Good
>70	Acceptable
>60	Questionable
>50	Poor
<50	Unacceptable

Table 4 Case processing summary

Case processing summary			
		N	%
Cases	Valid	105	100.0
	Excluded	0	0.0
	Total	105	100.0

Table 5 Cronbach's Alpha results

Concept	Cronbach's Alpha
IoT awareness FACTORS in Australia	0.938
opportunities of IoT application in Australia	0.950
Challenges of IoT application in Australia	0.828

"Challenges of IoT application in Australia" are the smaller number of questions when compared to the other two concepts, unfamiliarity of participants with the risks of IoT application and finally because those questions were the last part of the questionnaire the respondents might have been less attentive when compared with the first two sections.

Apart from Cronbach's Alpha, in order to test the suitability of the collected data for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is used. KMO specifies the amount of adjustment in variables triggered by factors in the questionnaire. Similar to Cronbach's Alpha, this measure is a number between 0 and 1 and a higher number means the factor analysis is valuable and a lower value is usually interpreted as a useless factor. Moreover, Bartlett's test of sphericity examines the total significance of the connections inside a correlation matrix and determines if it is appropriate to use factor analysis based on the correlation of matrices (Williams et al. 2010). Field (2013) ranks KMO values as the following: under 0.5 unacceptable, 0.5–0.7 average, 0.7–0.8 satisfactory, 0.8–0.9 great and above 0.9 outstanding. The KMO and Bartlett's test outcomes for the questionnaire are as the following in Table 6.

As see in Table 6, the KMO value for "Opportunities of IoT application in Australia" is within the outstanding range and "IoT Awareness Factors in Australia" is also within the great range for factor analysis and Bartlett's test also shows satisfactory results. The KMO for "Challenges of IoT application in Australia" is lower as expected because of the same reasons mentioned in the Cronbach's Alpha section.

Table 6 KMO and bartlett's test results

Concept	KMO	Bartlett's test
Opportunities of IoT application in Australia	0.908	Approx. Chi-Square 1658.591 df 231 Sig. 0.000
Challenges of IoT application in Australia	0.799	Approx. Chi-square 634.937 df 78 Sig. 0.000
IoT awareness factors in Australia	0.884	Approx. Chi-square 1608.719 df 210 Sig. 0.000

5.2 *Factor Analysis*

Factor analysis is a technique to group the collected data based on correlations of variables and identify a structure based on those groups. According to Thompson (2007) there are three drivers for using factor analysis; first it might be used for theory of structure, second, to check if variables are grouped as anticipated or not and finally, to estimate factor scores based on statistical analyses. Furthermore, Yong and Pearce (2013) argue that clustered data is easier to understand and variables with high correlations can be identified as factors. It is worth mentioning that there are two types of factor analysis: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). In EFA variables are ordered by simple measures to identify the factor structure however in CFA the factor structure is tested by observing variables (Suhr 2006). Lastly, the SPSS rotated matrix was used for factor analysis in this study and the outcomes are explained in the following.

5.2.1 Factor Analysis for IoT Awareness Factors in Australia

Two factors were identified using factor analysis in SPSS where the first factor accumulated 45% of total variance and the second factor stands for 11% as shown in Table 7.

As shown in Table 8 participants believed that IoT awareness should be focused on using recycled materials (0.806), using recyclable materials (0.773), using renewable materials (0.772), portability efficiency (0.731), long life (0.728), using less raw

Table 7 Total variance for IoT awareness factors in Australia

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	9.508	45.278	45.278	9.508	45.278	45.278
2	2.336	11.123	56.401	2.336	11.123	56.401

Table 8 Rotated component matrix for IoT awareness factors in Australia

	Component	
	1	2
Use recycled materials	.806	.113
Use recyclable materials	.773	.136
Use renewable materials	.772	.142
Have portability efficiency	.731	.129
Have long life	.728	.133
Use less raw materials	.725	.196
Have successful production cycles	.689	.354
Produce less waste and toxins	.592	.437
Shifting the mode of consumption from personal ownership of products to provision of services	.571	.288
Have good ethical principles	.566	.509
Are easy to add new software	.546	.426
Are easy to upgrade	.539	.381
Are easy to recycle	.503	.416
Reduce carbon footprint	.179	.841
Reduce air pollution	.183	.821
Reduce climate global warming	.173	.807
Sustain environmental standards and rules		.777
Reduce diseases and even death of humans	.291	.683
Have clean emissions	.325	.663
Use less energy	.415	.635
Reduce consumption and waste of resources	.420	.484
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

materials (0.725) and a successful cycle of production (0.689). For the second factor, reducing carbon footprint (0.841), reducing air pollution (0.821), reducing climate global warming (0.807), sustaining environmental standards and rules (0.777), reducing diseases and even death of humans (0.683), clean emissions (0.663) and less energy consumption (0.635) are grouped together.

After forming two groups of variables, a new factor for each of those groups was generated as the following: Firstly, based on the first variables group which were mostly associated with materials, a new factor named "Recycled and renewable

Table 9 First new factor for IoT awareness in Australia

Variables	Factor loading	New factor
Use recycled materials	0.806	3Rs
Use recyclable materials	0.773	
Use renewable materials	0.772	
Have portability efficiency	0.731	
Have long life	0.728	
Use less raw materials	0.725	
Have successful production cycles	0.689	

Table 10 Second factor for IoT awareness in Australia

Variables	Factor loading	New factor
Reduce carbon footprint	0.841	Clean emissions
Reduce air pollution	0.821	
Reduce climate global warming	0.807	
Sustain environmental standards and rules	0.777	
Reduce diseases and even death of humans	0.683	
Have clean emissions	0.663	
Use less energy	0.635	

materials" was generated as the first factor for IoT Awareness in Australia (see Table 9).

Secondly, for the second factor regarding IoT awareness in Australia, considering most variables are associated with reducing pollution and carbon footprint, the newly generated factor was named "Clean emissions" (see Table 10).

5.2.2 Factor Analysis for Challenges of IoT Application in Australia

Three components were chosen in factor analysis for the challenges of IoT application in Australia in SPSS, where the first component had 36% of total variance and the second and third components had 16% and 12% respectively (see Table 11).

As shown in Table 12, the rotated component matrix based on three components were put in three groups; the respondents identified "Increase marketing failure by perceived environmental irresponsibility" (0.876), "Increase scandals by perceived environmental irresponsibility" (0.843) and "Increase security and systems failures caused by environmental problems" (0.810) as the top three challenges of the first factor, the second group consists of the variables "Increase litigation and compliance breaches" (0.778), "Increase fraud" (0.765) and "Increase governance failure" (0.674) and the last group is comprised of the variables "Inflate costs" (0.844),

Table 11 Total variance for challenges of IoT application in Australia

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.697	36.133	36.133	4.697	36.133	36.133
2	2.091	16.083	52.215	2.091	16.083	52.215
3	1.675	12.882	65.098	1.675	12.882	65.098

Table 12 Rotated component matrix for challenges of IoT application in Australia

Rotated Component Matrix			
	Component		
	1	2	3
Increase marketing failure by perceived environmental irresponsibility	.876		
Increase scandals by perceived environmental irresponsibility	.843	.206	.143
Increase security and systems failures caused by environmental problems	.810	.266	
Increase supply chain crises due to suppliers' environmental problems	.783	-.190	.248
Increase transaction failure due to environmental liabilities	.657	.483	.124
Increase litigation and compliance breaches	.265	.778	
Increase fraud		.765	.119
Increase governance failure	.434	.674	.152
Increase number of new regulations including environmental		.461	
Inflate costs	.130		.844
Increase interest rates	.136	-.232	.814
Increase insurance crises due to environmental disasters	.386	.177	.642
Increase competition for and cost of raw materials		.379	.639
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 6 iterations.			

"Increase interest rates" (0.814) and "Increase insurance crises due to environmental disasters" (0.642) (see Table 12).

After forming three groups of variables, a new factor for each of those clusters was created as the following: Firstly, based on the first variables group which were mostly associated with failure, a new factor named "Increase Failure" was generated as the first factor for challenges of IoT application in Australia (see Table 13).

Secondly, for the second factor regarding the challenges of IoT application in Australia, bearing in mind that the majority of variables are related to breaches and fraud, the new factor was named "Increase Fraud" (see Table 14).

For the last cluster, as most of the variables are concerned with price rises and rates, the third factor was named "Raise Costs" (see Table 15).

Table 13 First factor for challenges of IoT application in Australia

Variables	Factor loading	New factor
Increase marketing failure by perceived environmental irresponsibility	0.876	Increase risks failure in business
Increase scandals by perceived environment al irresponsibility	0.843	
Increase security and systems failures caused by environmental problems	0.810	
Increase supply chain crises due to suppliers' environmental problems	0.783	
Increase transaction failure due to environmental liabilities	0.657	

Table 14 Second factor for challenges of IoT application in Australia

Variables	Factor loading	New factor
Increase litigation and compliance breaches	0.778	Increase fraud
Increase fraud	0.765	
Increase governance failure	0.674	

Table 15 Third factor for challenges of IoT application in Australia

Variables	Factor loading	New factor
Inflate costs	0.844	Raise costs
Increase interest rates	0.814	
Increase insurance crises due to environmental disasters	0.642	
Increase competition for and cost of raw materials	0.639	

5.2.3 Factor Analysis for Opportunities of IoT Application in Australia

Three components were set in factor analysis for opportunities of IoT application in Australia where the first component had almost 50% of variance, the second component accumulated 7% and the third component had 6% of the total variance (see Table 16).

Table 16 Total variance for opportunities of IoT application in Australia

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of variance	Cumulative %
1	10.902	49.557	49.557	10.902	49.557	49.557
2	1.600	7.273	56.829	1.600	7.273	56.829
3	1.368	6.219	63.049	1.368	6.219	63.049

The challenges factors, as shown in the following table, the rotated component matrix based on three components were grouped in three; variables of "Increase cost-effectiveness" (0.763), "Increase efficiency" (0.745), "Reduce risk management" (0.739) and other related variables were grouped in one cluster, the next group consisted of the "Reduce pollution" (0.836), "Reduce emissions" (0.83) and "Reduce carbon footprint" (0.766) variables. The last cluster contained the variables "Satisfy customer needs" (0.791), "Attract new opportunities" (0.773) and "Increase green strategy" (0.654) (see Table 17).

Following the creation of three groups of variables, a new factor for each of those collections was formed as the following: First, based on the first group which had variables mostly related to cost and efficiency, a new factor named "Growth of efficiency and productivity" was created as the first factor for opportunities of IoT application in Australia (see Table 18).

Table 17 Rotated component matrix for opportunities of IoT application in Australia

Rotated Component Matrix			
	Component		
	1	2	3
Increase cost-effectiveness	.763	.438	.221
Increase efficiency	.745	.376	.198
Reduce risk management	.739	.159	.228
Increase productivity	.724	.292	.297
Improve Corporate Social Responsibility	.676	.121	.366
Reduce paper usage	.643	.495	
Increase Triple Bottom Line – People, Planet and Profit	.643		.436
Reduce raw materials usage	.617	.516	.220
Reduce energy and water usage	.583	.471	.197
Enhance reputation	.483	.368	.277
Reduce pollution	.258	.836	.237
Reduce emissions	.221	.830	.346
Reduce carbon footprint	.266	.766	.266
Reduce health hazards	.332	.655	.159
Satisfy customer needs	.158	.141	.791
Attract new opportunities	.278		.773
Increase green strategy		.391	.654
Differentiate businesses	.208	.293	.622
Meet stakeholder expectations	.293	.287	.568
Attract quality employees	.404	.122	.547
Create new jobs	.319	.505	.541
Improve human rights	.320	.320	.359
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 7 iterations.			

Table 18 First factor for opportunities of IoT application in Australia

Variables	Factor loading	New factor
Increase cost-effectiveness	0.763	Growth of efficiency and productivity
Increase efficiency	0.745	
Reduce risk management	0.739	
Increase productivity	0.724	
Improve corporate social responsibility	0.676	
Reduce paper usage	0.643	
Increase triple bottom line—people, planet and profit	0.643	
Reduce raw materials usage	0.617	

Table 19 Second factor for opportunities of IoT application in Australia

Variables	Factor loading	New factor
Reduce pollution	0.836	Reduce emissions
Reduce emissions	0.830	
Reduce carbon footprint	0.766	
Reduce health hazards	0.655	

Table 20 Third factor for opportunities of IoT application in Australia

Variables	Factor loading	New factor
Satisfy customer needs	0.791	New opportunities
Attract new opportunities	0.773	
Increase green strategy	0.654	
Differentiate businesses	0.622	

Secondly, for the second factor concerning the opportunities of IoT application in Australia, because almost all of the variables were related to pollution and emission, the new factor name was chosen as “Reduce emissions” (see Table 19).

Third, for the last group, considering variables in this group were about needs and opportunities, the third factor was named “New opportunities” (see Table 20).

6 Discussion and New Findings

Before concluding the findings and analysis from the survey and answering the research questions, some important facts of the survey need to be highlighted: 105 valid questionnaires were collected using web-based and traditional methods and were then analysed by SPSS version 25 to generate new factors. 52% of participants were female and 48% were males; and over 80% of respondents were aged between 18 and 30 years old. The majority of the people in the survey had their studies in Information Technology, Science and Engineering, Management and Health Sciences. Over 80% of the participants had at least a Bachelor degree and almost all of them used smartphones and laptops to connect to the Internet. Furthermore, only five individuals were not familiar with the concepts of sustainability and Green Information Technology and over half of the participants had learned about those concepts from school, Internet, news media or higher education. While 68% of participants thought changing electronic devices frequently caused damage to the planet, only 8% firmly believed that doing this was not a contributing factor. Again over 80% saw education as one of the best methods of changing the mindset of people about sustainability and Green IT and at least 60% believed in raising awareness, Internet, social networking and regulations and guidelines to address those concepts; finally, in terms of familiarity and application of IT platforms, social networking was the dominant technology following by smart technology, cloud computing, drones and IoT. The first research question was: What are the environmental awareness factors of IoT application in Australia?

As Fig. 19 illustrates, the factor analysis from the survey shows that the environmental awareness factors are the 3Rs (recycled, recyclable and renewable materials) and clean emissions. The first factor generated after studying the variables, with over a 0.7 factor loading, use recycled materials, use recyclable materials, use renewable

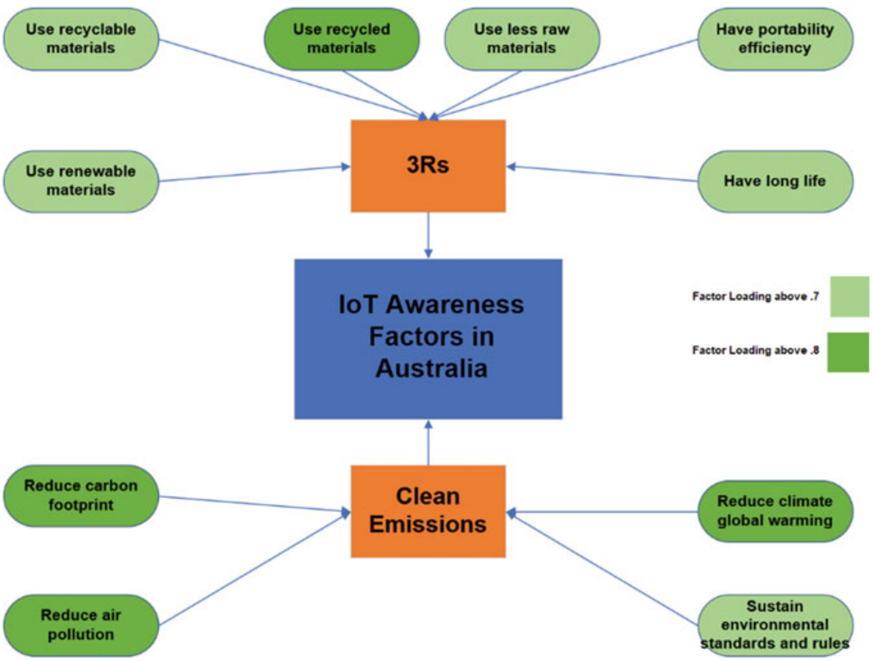


Fig. 19 Concept map for environmental awareness factors in Australia

materials, have a long life, have portability efficiency and use less raw materials. The second factor was created by reviewing variables with over a 0.7 factor loading, these were: reduce carbon footprint, reduce climate global warming, reduce air pollution and sustainable environment standards and rules.

The second research question was: What are the opportunities and challenges of IoT application in Australia? As this question has 2 separate parts (opportunities and challenges), the factor analysis was separately identified using the answers from the survey.

Firstly, the opportunities of IoT application in Australia based on factor analysis are: growth of efficiency and productivity, emission reductions and new opportunities. The first factor (growth of efficiency and productivity) was generated after analysing variables with factor loading of over 0.7, these were: increase cost-effectiveness, increase efficiency, reduce risk management and increase productivity. The second factor (emission reduction) was generated after reviewing factors with loading of over 0.7, these were: reduce pollution, reduce emissions and reduce carbon footprint. The last factor (new opportunities) was again created by reviewing factors with a loading of over 0.7 these were: satisfy customer needs and attract new opportunities. The concept map for the opportunities of IoT application in Australia is as shown in Fig. 20.

On the other hand, for the challenges of IoT application in Australia the following factors were concluded: increase of risks and failures, rise of fraud and costs. The first factor was generated by analysing related factors with over a 0.7 factor loading, these were: increase marketing failure, increase scandals, increase security and systems failures and increase in supply chain crises. The second factor, rise of fraud, was shaped by examining related factors with over 0.7 factor loading, these were: increase litigation, compliance breaches and fraud. The last factor was made by inspecting the set of related factors loading above 0.7, these were: inflate costs and interest rates. The concept map for challenges of IoT application in Australia is shown in Fig. 21.

7 Study Limitations, Future Research and Recommendations

This study presents new knowledge regarding Green IT awareness and application in Australia but there were some limitations doing this study which are discussed as follows.

7.1 Study Limitations

The main limitation doing this study was associated with the survey method and survey population. Firstly, a web-based questionnaire was implemented but once

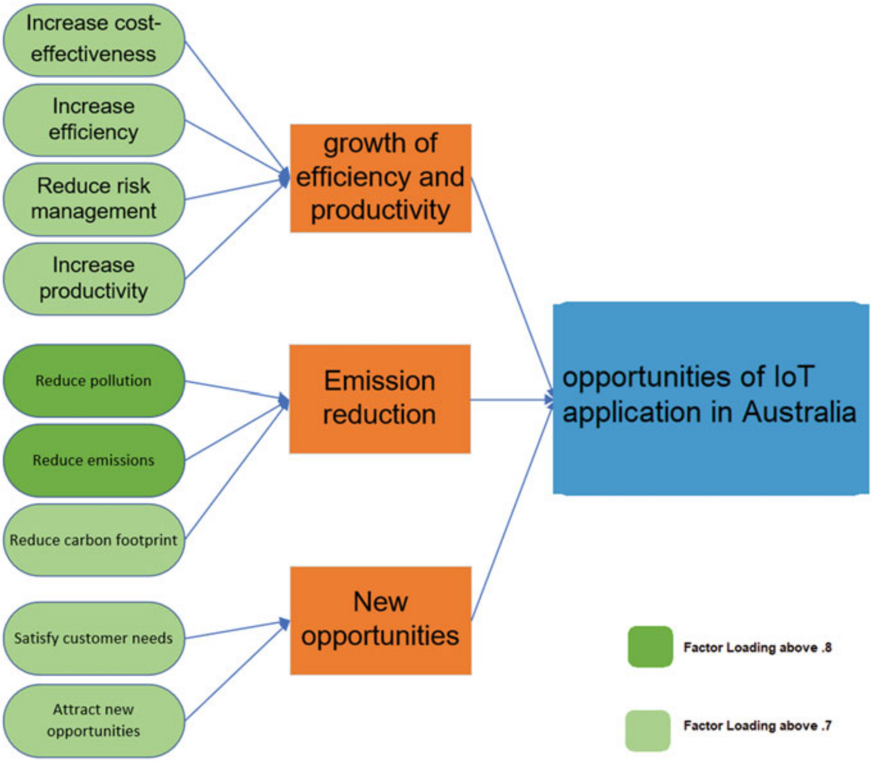


Fig. 20 Concept map for opportunities of IoT application in Australia

it became apparent that there was a low response rate and the questions were not answered well, the researcher decided to use a traditional method to gather data. This brought the second limitation as a traditional method has several limitations including that the survey population cannot be as diverse or random to the same degree as the web-based survey.

The limitation to choose a broad survey population resulted in the second limitation of this study where the scope of research had to be limited to Australians living in Western Australia. Therefore, the findings may not be applicable to other populations outside this research scope. Also, this study is not industry-specific and further studies are needed to focus on specific applications of IoT in industries. Lastly, the number of valid respondents was limited to 105 due to the low response rate of the web-based survey and difficulty of conducting a large scale traditional survey.

This study was conducted over a short period of time and although the findings and literature review are distinctive and significant in terms of theoretical and practical contributions, the researcher believes that given more time and resources, including a broader sample size, the study would've been more in-depth.

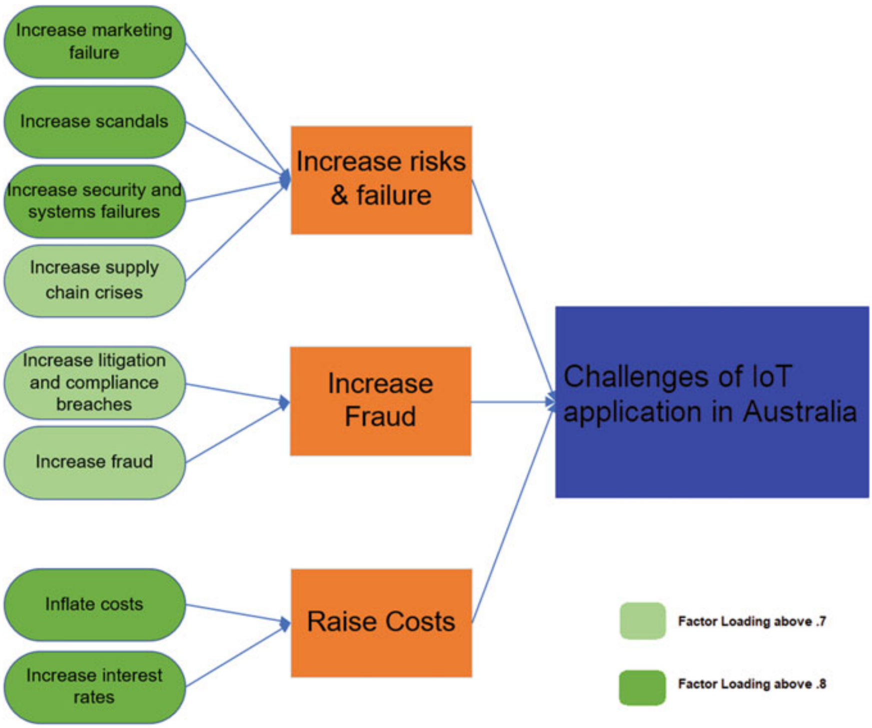


Fig. 21 Concept map for challenges of IoT application in Australia

Another limitation of this study was related to the limited resources of similar work and literature regarding IoT applications, especially in Australia. The IoT concept and related technologies are still in their initial phases and the effects of IoT on sustainability and Green IT initiatives are still not thoroughly identified and more research and time are needed to have a better understanding of this new concept. This lack of knowledge is also shown from the respondents: merely 20% of the participants were using IoT technology in their daily life.

7.2 Future Research

The limitations of this study can be used a guideline for future research. Some of the areas for improvement and focus for future research are as follows:

Firstly, a larger sample size with broader research scope would add more depth to future research. Using professional and well-known companies to collect data or/and negotiate with medium/large companies to use their human resources for conducting the survey would be beneficial to reach a larger sample and scope. Also, using a hybrid survey method (traditional and web-based survey) would provide more depth to the sample population and consequently more accuracy to the outcome for generalisation. Green IT and sustainability applications and technologies like IoT have a broad range of applications in diverse industries in Australia. Researching a specific industry and a specific technology would establish grounds for a better understanding of these technologies. For example, IoT application in mining sector needs more in-depth research and study for a much-needed increase in productivity and sustainability.

7.3 Recommendations

Based on the literature review, the findings of the survey and factors derived from data analysis, a number of recommendations can be suggested to government, businesses and academics in Australia as the following:

Firstly, the local and federal government bodies around Australia are expected to address productivity, efficiency and environmental challenges and Information Technology concepts like IoT can assist in these areas. As suggested by 81% of the participants of the survey, education is the best tool to change the mindset of people regarding those issues. Authorities in Australia need to take a new educational approach for schools and universities to raise awareness and knowledge regarding sustainability and Green IT initiatives. Furthermore, 60% of participants in this study believed that regulations and guidelines are needed to address sustainability and Green Information Technology which again highlights the importance of government‘s involvement. Studying laws and guidelines of leading countries in terms of environmental performance, sustainable development and technological advancement is recommended to gain a better understanding of the possible steps and laws needed to address sustainable development with the help of Green IT. Lastly, government departments and agencies need to be a role model for implementing green initiatives in Australia. Although there are numerous approaches for green initiatives, one good starting point is the Sustainable Development Goals (SDGs) set by the United Nations. Australia‘s ranking is not satisfactory (37th in the world), with some of the worst performances in Responsible Consumption and Production and Climate Action goals. The Australian government need to take more calculated actions to address the SDGs and other green initiatives.

The second recommendation is for businesses in Australia. Information Technology is advancing at a much faster pace than ever before and businesses that fail to cope with quick adoption and implantation of new technologies are doomed to go bankrupt. As explained throughout this study and in the findings from the survey, technologies like Big Data and IoT can benefit businesses in many ways: reducing the cost of energy consumption by implementing green energy, building a strong brand image, attracting talented employees, creating new opportunities, increasing efficiency and productivity and, ultimately, a heathy financial position. It is important to note that although investing and implementing in new green technologies is recommended businesses need to be aware of the challenges and problems of these innovations. As shown in this study, people are concerned about fraud and failures caused by IoT and other new technologies. Businesses need to invest in privacy and security features to win the trust of clients and customers. Lastly, as shown in the survey findings, education, training and workshops are essential to address IoT issues and benefits and raise awareness regarding those matters.

The last recommendations are for academics and scholars. Firstly, there are numerous aspects of Green IT that need further study and investigation; as discussed in the "Future Research" section, researchers and scholars need to look at different angles and aspects of technologies and try to find better solutions for implementing new technologies. For example, there are number of challenges in IoT like non-unified standards, architecture and failure and fraud that need immediate attention from scholars and academics. Apart from that, academics are responsible to educate skilled people for designing and implementing new technologies; without skilled professionals, the progress of adapting new technologies will be halted. Ethics must not be left out when educating professionals; points like property right of information, integrity of information, the right of privacy and the right of access need to be addressed in all courses and units of IoT or any other IT related units. Lastly, the majority of the survey participants believed education and awareness are two of the most important drivers to change the mindset of people about sustainability and Green Information Technology. It is recommended that academics prepare programs and mandatory units to discuss these matters.

8 Conclusion

This study examined and investigated IoT application from an Australian perspective to examine awareness, opportunities and challenges factors of IoT application as a Green Information Technology. An online survey was employed to study Western Australia citizens' opinion and knowledge on various topics regarding IoT application as a Green Technology. One hundred and five valid questionnaires were returned and based on the outcomes of the survey, which were analysed by SPSS version 25, two factors were identified for IoT environmental awareness, three factors for opportunities and three factors for challenges of IoT application were also generated. A set of recommendations for government, businesses and academics are suggested for future works including a stress on education and training. This study was limited to an online survey, limited resources and lack of knowledge and awareness regarding the concept of IoT and the research scope. Further research will be carried out in the future to examine the IoT application with vast responses from Australia and other countries to compare and construct the results.

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Energy Efficient Fault Tolerant Topology Control for IoT Using Variable k-Connectivity

Mitsumasa Ota, Ryuichi Takahashi, and Yoshiaki Fukazawa

Abstract In wireless IoT networks, when each node communicates with maximum power, power consumption increases unnecessary. Therefore, the transmission power of each node is adjusted using topology control. Because topology control decreases the number of edges between nodes, the fault tolerance may decline. One solution is to employ fault tolerant topology control using k-connectivity. Existing fault-tolerant topology control assumes that a network is constructed for one domain and the environment has a fixed k value. With a fixed k value, extra links are prepared, and power consumption increases. On the other hand, since various communications are shared in an IoT environment, the connectivity requirements change. Consequently, setting the k value for each pair of nodes according to the importance of data can eliminate extra links and reduce power consumption. Herein a method is proposed to realize topology control using a variable k value. To obtain a solution by the genetic algorithm, we propose an encoding scheme and define a fitness function. Simulation experiments demonstrate that the proposed method can construct a more power-efficient topology than the existing topology control method.

Keywords Internet of things · Wireless sensor network · Topology control · k-connected network · Genetic algorithm · Fault tolerant network · IoT gateway

M. Ota (✉) · Y. Fukazawa
Waseda University, Tokyo, Japan
e-mail: m_ota@fukazawa.info.waseda.ac.jp

Y. Fukazawa
e-mail: fukazawa@waseda.jp

R. Takahashi
Ibaraki University, Ibaraki, Japan
e-mail: ryuichi.takahashi.office@vc.ibaraki.ac.jp

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1 Introduction

In an Internet of Things (IoT) environment, resources such as radio frequency identification (RFID), sensors, and actuators installed in various "things" communicate with and control each other (Luigi et al. 2010). IoT is rapidly spreading due to the simultaneous miniaturization of power devices and the development of new communication technologies (Rawat et al. 2016). Currently, IoT environments range from small scale IoT (called nano IoT) to global scale IoT (Yuichi et al. 2014). By 2020, it is predicted that 50 billion devices will be connected to the Internet (Evans 2011).

Many devices are driven by batteries. Although numerous resources exchange data, not all can interconnect directly with geographically remote resources due to limited battery capacities. In such cases, gateways are used. Figure 1a shows a configuration without a gateway, where a device must be capable of long-distance communication to transmit data directly to other devices. Figure 1b shows a configuration with wireless multi-hop communications using gateways. A gateway functions as a relay point for communications, allowing devices to communicate. Besides reducing the required communication distance for each device, gateways can support device miniaturization and reductions in cost and power consumption.

In a wireless network using gateways, it is inefficient for each gateway to communicate at maximum power. Hence, the gateway topology is controlled at each gateway to optimize the power consumption. This technique minimizes power consumption in multi-hop communications because the transmission power of each node is adjusted to minimize the power consumption in the environment while maintaining the required network connectivity. When topology control lowers the power consumption, the density of the links between the gateways is reduced. Consequently, the fault tolerance of the network decreases.

In wireless multi-hop communications, multiple paths are required between two points in a network to prevent disconnection due to node failure. A fault-tolerant topology reduces power consumption while ensuring the required fault tolerance. One such control technique is k-connectivity. When there are k independent paths

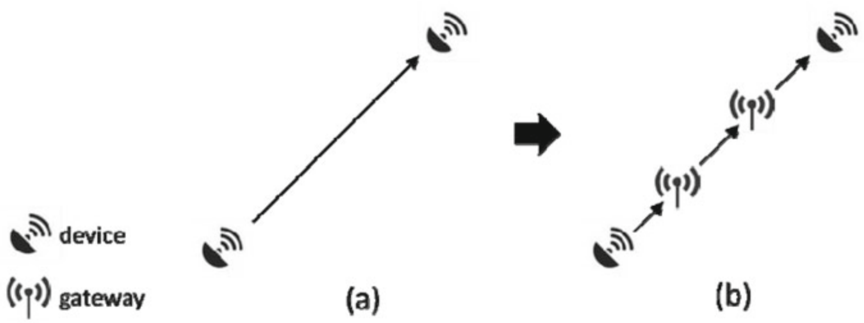
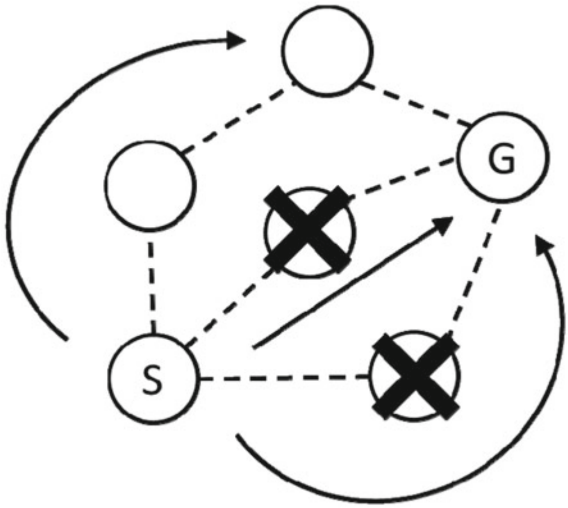


Fig. 1 Network configuration **a** without and **b** with gateways

Fig. 2 3-connected nodes



(paths that do not share nodes other than the start and end points) from node S to G, S and G are k-connected. Since the connection between k-connected nodes is maintained even if nodes up to k − 1 are removed, the communication between S and G is tolerant to at least k − 1 node failures. If two arbitrary nodes in the graph are k-connected, the graph is called a k-connected graph.

Figure 2 shows that nodes S and G are connected by three independent paths (three-connected). The connection between S and G is maintained when two nodes are removed. For example, one path is maintained even if the nodes with the crosses in Fig. 2 are removed.

In a k-connected graph, the degree of each node (the number of edges joined to the node) must be greater than or equal to k. Because each node is connected to many nodes, the power consumption increases as k increases. Therefore, power consumption and fault tolerance have a trade-off relationship.

Existing topology control methods proposed in the fields of wireless sensor networks (WSNs) and ad hoc networks use a fixed k value in the environment. In these fields, the network is constructed for certain domain. Therefore, the importance of exchanged data is similar. However, an IoT network is used for multiple domains, resulting in an exchange of diverse data with varying levels of importance. Consequently, a fault tolerance suitable for each type of data is required.

As an example, consider a factory system controlled by IoT. This system consists of production machines, fault detection sensors, and sensors for energy usage and production volume. These devices are interconnected via wireless gateways. This system allows the production volume to be monitored, the energy consumption to be analyzed, and the production line to be halted immediately if a machine fault occurs. In this example, data such as detection of a machine fault is highly important and requires real-time transmission. Therefore, a high fault tolerance is necessary to prevent a delay due to a gateway failure. However, not all data in the system needs to be real-time. A delay due to retransmission is permitted when a high degree of real-time performance is not required such as monitoring the energy consumption and production volume. Maintaining a high fault tolerance for all information can lead to inefficient power consumption.

Similar to the above example, IoT must consider fault tolerances based on the importance of the type of data. Using a fixed k value like the existing approach results in excessive redundant links, decreasing the power efficiency. Herein we propose a method to reduce the power consumption while maintaining the required connectivity by setting the value of k for each set of devices based on the importance of data. The aim of our method is to reduce total power consumption in network by eliminating extra link with variable k-connectivity.

The remainder of this paper is organized as follows. Section 2 describes related works. Section 3 details the problem, while Sect. 4 proposes a method to solve the problem. Section 5 explains the experiments to evaluate the proposed method and discuss result in Sect. 6. Finally, Sect. 7 provides conclusions.

2 Related Work

Previous studies have investigated networks using gateways. Kim et al. (2015) investigated a method to solve the resource allocation problem to a gateway. Their method converts the resource allocation problem into a minimum spanning tree problem, which is solved by a genetic algorithm (GA). Although their method calculates the tree topology to minimize the data transmission cost, it does not assume the occurrence of gateway failure. With regard to fault tolerant topology, their method differs from ours.

Karthikeya et al. (2016) proposed an optimization method for gateway placement. Their approach minimizes the installation cost of gateways by optimizing gateway placement. The optimum gateway placement is calculated only where devices are deployed. However, we propose a method to optimize the topology in an environment where devices and gateways are already deployed.

Ismail et al. (2012) examined a resource allocation method assuming a mobile network in a device called a mobile terminal. In their research, resource allocation means to determine the access point that each mobile terminal is connected. Since their method is a distributed algorithm to find an optimal solution for each partitioned network, one advantage is that a central resource manager is unnecessary. In their method, a mobile terminal corresponds to an IoT device, and the network base station and access point operate like a gateway in an IoT environment. Although they handle similar problems as our research because both studies assume that device communications use relay points, the other assumptions between the two studies differ. In their method, each mobile terminal can connect to multiple networks simultaneously, whereas in ours, each IoT device is allocated to one gateway chosen from the candidates. Additionally, they do not assume node failure.

Other studies have examined tolerant topology control using k-connectivity. The problem of finding the minimum cost k-connected graph is NP-hard. Many approximation algorithms have been proposed (Hajiaghayi et al. 2003; Khuller 1998).

Li and Hou (2004) proposed FGSS and FLSS, which are fault tolerant topology control algorithms with k-connected graphs. These algorithms extend the Kruskal algorithm (Kruskal 1956), which is a basic algorithm to find the minimum spanning tree (one-connected graph with the minimum sum of path costs). It constantly monitors the network and judges whether the network maintains k-connectivity.

Li et al. (2005) proposed the CBTC algorithm to maintain k-connectivity in a network. In the topology obtained by this algorithm, k-connectivity is maintained between two arbitrary nodes. However, k-connectivity is unnecessary between two arbitrary nodes as it is sufficient to maintain k-connections only between nodes that communicate. Both of these algorithms can determine a k-connection graph. In other words, they do not consider which nodes are communicating.

By contrast, Xiao and Zhou (2013) proposed an FTCGA algorithm to reduce energy consumption by guaranteeing k-connectivity only between sensor nodes and sink nodes in a WSN. This method calculates the topology with a reduction in redundant links while maintaining k-connectivity only between communicating nodes using a GA.

In fault tolerant topology control, reducing the power consumption by eliminating unnecessary links is emphasized. On the other hand, our method aims to reduce links while maintaining the required connectivity by setting the k value for each pair of devices that communicate instead of a fixed one for the environment.

3 Problem Definition

The problem environment is constructed using two kinds of devices: an IoT gateway and a gateway. Devices communicate in the deployed environment.

Gateways function as relay points of communication between devices. The gateway g_i has its own position (x_i, y_i) and a maximum transmission radius $r_{\max}(g_i)$, which is the maximum distance that data can be transmitted. $r_{\max}(g_i)$ has a static value. The actual transmission radius $r(g_i)$ can be changed in the range $0 \leq r(g_i) \leq r_{\max}(g_i)$. As shown in Fig. 3, the gateway can transmit data to other gateways that are within the transmission radius. However, it cannot transmit data directly to gateways that are beyond its transmission radius. In other words, there is an edge from gateway g_i to gateway g_i if $r(g_i) \geq dis(i, j)$, where $dis(i, j)$ is the distance between g_i and g_i. Devices, which transmit and receive data, are the end points of a communication path. The device d_i is allocated to one gateway $al(d_i)$ to communicate via gateways. Every device has a list of allocatable gateways, which must have at least one element.

From these conditions, the problem environment is represented by the directed graph G. G is expressed as

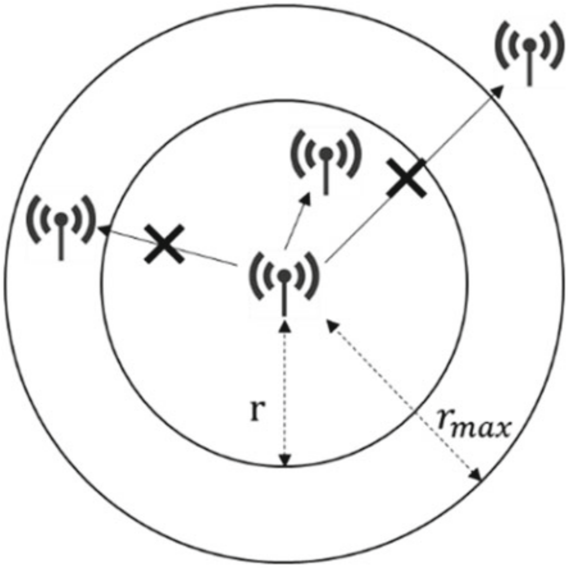


Fig. 3 Gateway can transmit data within the transmission radius

$$
\begin{aligned}
&G = (V, E)\\
&V = V_d \cup V_g\\
&V_d = \{d_n | n = \text{device}ID\}\\
&V_g = \{g_n | n = g \text{ ateway } ID\}\\
&E = E_d \cup E_g\\
&E_d = \left\{(d, g) | d \in V_d, g \in V_g, g = al(d)\right\}\\
&E_g = \left\{(g_i, g_i) | g_i \in V_g, g_i \in V_g, r(g_i) \geq \text{dis}\left(g_i, g_j\right)\right\}
\end{aligned}
$$

The directed graph G is constructed by a set of nodes V and a set of edges E. V contains a set of device nodes V_d and a set of gateway nodes V_g. E consists of two edge sets: E_d and E_g. Each edge (d, g) included in E_d represents the allocation of device d to gateway g. Each edge (g_i, g_i) included in E_g means that gateway g_i can transmit data directly to gateway g_i

For such an environment, an input is given by $T = \left\{t = \left(d_i, d_j, k\right) | d_i, d_i \in V_d, k > 0\right\}$ $t \in$ T represents a pair of devices that communicate and their required connectivity. $t = \left(d_i, d_j, k\right)$ means that k-connectivity is required between device d_i and d_j. Because the k value can be set for each pair of devices, our method differs from existing fault tolerant topology control methods using a fixed k value.

The output is the allocation $al(d)$ of all devices and the transmission radius $r(g)$ of all gateways. Since the transmission power in wireless communication is the square of the transmission distance, the power consumption in gateway g_i is represented by $\mathrm{e}(g_i) = \mathrm{r}(g_i)^2$. In this paper, we aim to find $al(d)$ and $r(g)$ to minimize the sum of the power consumption in the environment while maintaining the required connectivity.

4 Proposal Method

We propose a method to obtain solutions to the problems defined in Sect. 3. Since the problem of finding the minimum cost k-connected graph is proven to be NP-hard, our method uses a GA to determine the transmission radius of each gateway and allocation. GA is a heuristic algorithm for approximate solutions by evolving a set of candidates encoded by a process that imitates evolution (Beasley 1993). In this paper, we define the encoding scheme and the fitness function to evaluate the candidate that minimizes the power consumption while maintaining the required connectivity. In addition, the generation of the next candidate is realized by a one-point crossover and mutation. The encoding scheme and fitness function are described below.

4.1 Encoding Scheme

In a GA, a sequence, which is called the code of candidates, represents the candidates. In this subsection, we describe the encoding scheme.

Each candidate is represented by the following code C.

$C = Gene[D + G]$

$Gene[i] = \begin{cases} al(d_i) & (i < D) \\ r(g_{i-n}) & (i \geq D) \end{cases}$, where D is the number of devices and G is the number of gateways. $al(d_i)$ represents the ID of the gateway in which the device d_i is allocated and $r(d_i)$ represents the transmission radius of gateway g_i. That is, the code of each candidate

is an integer sequence where the length is the sum of the number of gateways and devices. The code is divided into two. The first (former) part shows the gateway where each device is allocated, while the second (latter) part shows the transmission radius of each gateway.

Figure 4 shows an example of encoding, where edges between gateways are omitted for simplicity. The device d_0 is allocated to gateway g_2, so Gene[0] = 2.

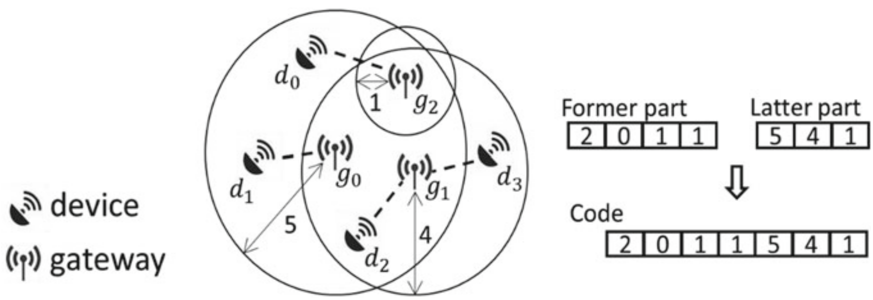


Fig. 4 Encoding example

Similarly, the former part is "2011" for the other devices. Because $\mathrm{r}(g_0) = 5$, $Gene[4] = r(g_{4-4}) = r(g_0) = 5$. Considering the other gateways in the same manner, the latter is "541." Thus, the code representing the state in Fig. 4 is "2011541."

The encoding considers two properties: locality and heritability. Locality is the influence of each code element on the solution structure. Encoding with a low locality means that a small change in the code may greatly alter the structure of the solution. Heritability is how much a child candidate inherits the characteristics of a parent by crossover. A low heritability means that a child will not inherit the parent's characteristics, preventing the child from obtaining a better solution.

Regarding locality in our encoding scheme, each element of the former part represents the allocation of one device. Each element of the latter part represents the transmission radius of one gateway. If an element of the former is changed, only one device allocation is changed. The topology of the other part is not affected. Because the transmission radius is related only to the existence of the edge between a gateway and its adjacent gateways, a topology change due to a change in the transmission radius is local. Therefore, the locality of our encoding scheme is high.

In this encoding scheme, a child topology inherits the edge in the parent topology corresponding to the code inherited from the parent. Consequently, it also has a high heritability.

4.2 Fitness Function

This subsection describes the fitness function. Fitness represents the quality of the candidate in the GA. Solutions are obtained from candidates with a higher fitness when calculated by the fitness function. In our method, the fitness function is defined to evaluate whether a candidate minimizes the power consumption while maintaining the required connectivity.

The fitness function is expressed as

$$
\begin{aligned}
\text{fitness} &= \sum_{g_i \in V_g} e(g_i) + \sum_{t \in T} p * s(t) \\
\mathrm{e}(g_i) &= \mathrm{r}(g_i)^2 \\
p &= \sum_{g_i \in V_g} \{r\mathrm{max}(g_i)\}^2 \\
s(t) &= \max\big(t \cdot k - n_{\text{path}}(t \cdot d_i, t \cdot d_i), 0\big)
\end{aligned}
$$

The first term represents the total power consumption. Candidates with low values consume less power.

The second term represents a penalty when the required connectivity is not satisfied. Here, $s(t)$ represents the number of missing paths for $\mathrm{t} = \left(d_i, d_j, \mathrm{k}\right)$. $n_{path}\left(d_i, d_j\right)$ represents the number of independent paths existing between the gateways to which the devices $d_i\ and\ d_i$ are allocated. When the value does not satisfy the required connectivity, $s(t)$ returns the number of missing paths. p is a penalty when the required connectivity is not satisfied. By setting the penalty proportional to the number of missing paths, whether a candidate satisfies the required connectivity with a lower value can be evaluated. In our method, because an approximate solution is obtained by the GA, the obtained solution does not necessarily satisfy the required connectivity. However, since the value of p is equal to the total power consumption when each gateway communicates at its maximum transmission radius, candidates that do not satisfy the required connectivity are always evaluated lower than candidates that satisfy it.

5 Experiment

Simulation experiments were conducted to evaluate whether the proposed method reduces the power consumption. In the experiment, topologies were obtained for randomly generated inputs. The required connectivity k was $1 \leq k \leq 3$.

Experiment 1 used the case where 10 environment s consisting of 20 gateways and 50 devices were randomly generated. The power consumption for three methods were compared: the proposed method, the FGSS algorithm (Li and Hou 2004), and without topology control. ("Without topology control" represents the case where each gateway communicates at its maximum transmission radius.) In Experiment 2, the calculation times between FGSS and the proposed method were compared by changing the number of gateways for 100 devices. (The calculation time means the time from inputting the environment to outputting the device allocation and transmission radius).

The experiments were conducted on a PC (Intel® Core™ i5 CPU M560 2.67 GHz and 4.00 GB memory) running on Windows 10 (32 bit). In the GA application, the number of candidates was $N = 50$, the number of selected candidates was $N_{select} = 10$ the maximum number of generations was $gen = 50$, and the mutation probability was $P_M = 0.10$.

The ability of the proposed method to reduce power consumption was evaluated by comparing it to the FGSS algorithm (existing fault tolerant topology control) and the case without topology control. Figure 5 shows the total power consumption in the topology generated with 20 gateways and 50 devices. A value of 1 represents the power consumption when a gateway communicates at a transmission radius of 1 m. And the execution times to calculate the topology between the proposed method and FGSS were compared. Figure 6 shows the execution time for 100 devices.

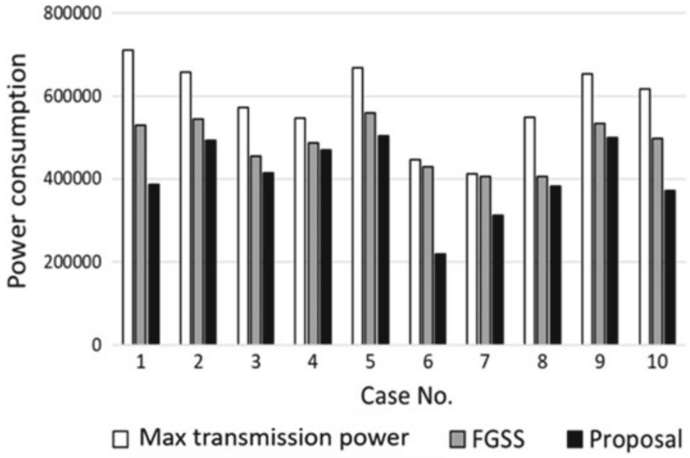


Fig. 5 Power consumption

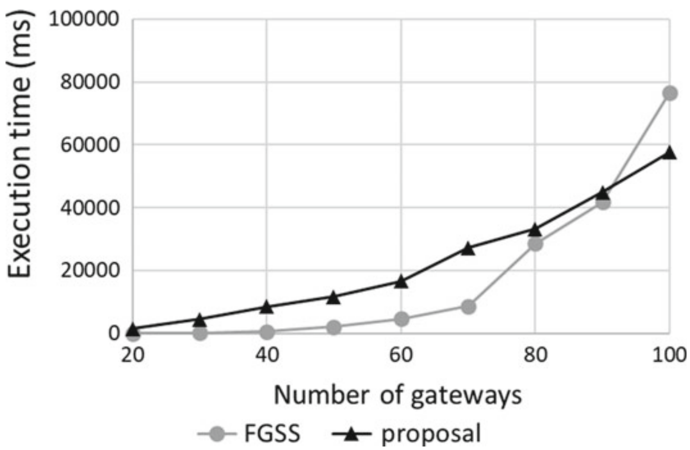


Fig. 6 Execution time

6 Discussion

In this section, we will discuss the results of the experiment in Sect. 5. Review the results for power consumption and execution time, and discuss the validity of the method.

6.1 Power Consumption

Figure 5 show the proposed method reduces the power consumption. Compared with the configuration without topology control, FGSS reduces the power consumption by about 15%, but the proposed method reduces it by about 30%. The proposed method provides a topology with a higher power efficiency. In FGSS, because three-connectivity is guaranteed between all nodes, even devices that do not communicate with each other have three connections. As a result, the power consumption in FGSS increases as the number of links increases. On the other hand, the proposed method reduces the links for parts that do not require a high connectivity, which improves the power efficiency.

In some cases, FGSS does not significantly reduce the power consumption (Fig. 5, cases 6 and 7). This may be because the topology without topology control is similar to the k-connected graph. Thus, the k-connectivity cannot be maintained if the transmission power is reduced. Moreover, the power consumption of the proposed method is closer to that of FGSS in cases 3 and 8. It is speculated that in these cases, the largest value of $k = 3$ is the required connectivity. Hence, setting k individually does not have a significant impact on removing unnecessary connections.

6.2 Execution Time

When the number of gateways is small, the proposed method has a longer execution time than FGSS. Since the execution time of FGSS is proportional to the number of edges in the graph (Li and Hou 2004), the execution time increases exponentially as the number of gateways increases. By contrast, increasing the number of gateways in the proposed method has a small effect.

6.3 Validity

The results for power consumption show that the proposed method can provide a topology with a higher power efficiency. Additionally, the effect is greater in the case where the required connectivity varies. The execution time of proposal method is shorter than FGSS in the large-scale environment. It means the proposed method is useful in the IoT, where more devices need to be considered. The proposed method can calculate the topology within a practical execution time.

From these, it can be concluded that the proposed method is particularly useful in a large IoT environment with various domains.

Also, the k-value of the proposal need to be set before execution. The value should be calculated from execution time for recalculation and probability of node failure.

7 Conclusion

Multi-hop communications using gateways are implemented because individual device constraints prevent all devices from communicating directly with each other. The existing fault tolerant topology control uses k-connectivity, but it assumes communications occur between homogeneous devices at a fixed k value. However, the required connectivity varies in the IoT since communications occur between heterogeneous devices.

Herein we propose a method that employs a GA and varies the k value for each pair. Simulation experiments show that our method can reduce power consumption. Our method produces an energy efficient topology in a calculation time similar to the existing method. For a dynamic IoT, the time efficiency of the algorithm should be improved.

In the future, the practicality of the method in an actual IoT environment should be experimentally investigated as this study is a simulation in a randomly generated environment. Also, in this method, the k-value must be given as a parameter. It is necessary how to calculate the value of k based on user requirements.

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Green Technology and Sustainability in Australia

Elias Saber

Abstract Due to rapid technological developments world is undergoing a drastic change and this change is forcing not only organizations but also citizens to pay more attention to the negative effects they are imposing on the environment directly or indirectly. This concern is making them more vigilant than in previous years and has placed on them the responsibility to be more sustainable and change their mindset as much as possible to achieve greater sustainability. The concept of sustainability has been established in order to protect, restore and maintain natural resources and give a new perspective to their usage as they are not limitless. If we want future generations to have adequate resources for their needs, as we now do, alternative ways must be found to use these resources responsibly, as well as utilizing renewable energy sources. Moreover, sustainability can help to ensure people's wellbeing, health and economic growth within a society. Hence, in this research, we examine people's awareness of sustainability, the importance of educating people in regard to sustainability, and whether this education brings about any significant changes in the way that organizations do business particular in terms of employees' adoption of sustainable practices. Moreover, this research investigates the extent to which people are aware of the advantages and risks associated with the adoption of sustainability. In this study, we assess the advantages and disadvantages of green technology in Australia, as well as people's awareness of sustainability and green IT. Specifically, our research objective is to assess the advantages and disadvantages associated with the adoption of green IT in Australia. Adopting a deductive approach, an online survey was conducted using Qualtrics for the data collection, Survey questionnaire items were designed to elicit from participants information related to their level of awareness of sustainability and green technology, and the advantages and disadvantages of adopting green IT in Australia. IBM SPSS was used to analyse the collected data, and the results of the survey are presented in detail. For the purposes of this study, the quantitative methodology was adopted. Furthermore, like any other research, this study has its own limitations in terms of sampling, time constraints and incomplete questionnaires in some cases. Moreover, the response 'Maybe' in answer to the question "How much would the regular changing of the device affect

E. Saber (✉)
School of Management, Curtin University, Perth, Western Australia, Australia
e-mail: elias.saber.k@gmail.com

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the environment?" indicates that people's awareness is not yet strong enough to effect a change in attitude in favour of sustainability. This demonstrates that a greater effort must be made to raise public awareness of sustainability and shift the current mindset. Future research could investigate effective ways by which such awareness could be increased.

Keywords Green · Technology · Sustainability · Awareness · Environment · Efficiency · Renewable resource · Governance · Development · Management · Australia

1 Introduction

The use of the term 'Green Information Technology' has become more widespread over the past few years and its importance has motivated many researchers to make efforts to change people's mindset in favour of 'going green'. To date, the paths taken by organizations and businesses in this direction have been impressive. However, there is still a long way to go before we can ensure that our environment is pleasant, safe and sustainable not only for ourselves, but also for future generations. Manufacturing companies are increasingly under pressure to produce less waste and minimize the negative impacts of their products on the environment. Hence, businesses these days need to consider the design and manufacture of their products as well as the disposal of technological devices. Therefore, strict adherence to rules and regulations must be made mandatory and the sooner we apply the desired changes, the sooner we will be able to address effectively the current problems that our society is facing regarding the environment. Increasingly, companies are adopting sustainability in their operations and this in turn enables them to align their performance with Green IT standards.

Natural resources, as we know, are not infinite and the rate at which these resources are being irresponsibly used and exploited has prompted many environmental conservatives to address this problem and, in an attempt, to provide practical solutions. The good news is that, although the term 'Green IT' emerged relatively recently, numerous countries are becoming more aware of the term and trying so hard to adopt this practice. Moreover, as part of the process, staff of those companies are becoming more vigilant and recognise the need for living a more sustainable life. However, in order to ensure a better future for coming generations, the attitudes of companies, organisations and the general public must change in order for the shift towards sustainability to be successful.

Having said that, it is worth mentioning that sustainable development does not concern environmental issues only; it is also linked to many other aspects of our daily lives: communities, business operations and the economy, to name a few. As will be discussed later, achieving a balance among economy, environment and people is the key to meeting the desired expectations. This ideal state of balance can be achieved through specific actions and policies.

This chapter consists of eight sections: Introduction; Sustainability and Green IT; Research methods and research question; Results; Discussion; Future research and limitations; and Conclusion.

2 Sustainability and Green IT

Over the past few years, the notion of sustainability has become clearer; basically, sustainability refers to the ability to maintain a safe and healthy balance between environmental, social and economic elements both locally and globally. The Brundtland report issued in 1987 by the World Commission on Environment and Development (WCED) offers this definition: "Sustainable development is the development that meets the needs of present without compromising the ability of future generations to meet their own needs" (Kohn, Chang, Karduck, & Televski, 2010, p. 286). Despite this very precise definition, other researchers have attached various meanings to the term, resulting in broad and sometime complex definitions. Some see it as the relationship between humankind and nature (Kuhlman & Farrington, 2010). Sustainability encompasses three main areas impacted by human activities: environmental, social and economic. Moreover, it is linked to the responsibility for leaving to future generations the limited resources of the planet. Hence, we should retain a reserve supply whenever we expend natural resources (Kuhlman & Farrington, 2010).

The notion of reserving some of the limited resources will help to safeguard the economy and society in the long run. This is vital if individuals and organizations are planning to have a sustainable future (Heiberg, 2012). In addition, (Beilharz & Hogan, 2006) it is essential that natural resources be conserved by means of ecological restoration, management of population and assessment of environmental impact.

Government and businesses worldwide have come to recognise the importance of sustainability. This concept not only refers to safeguarding the environment but is also linked to liveliness and ecological stewardship; organizational stewardship and human resources; and achievement of operational and economic goals (Sheehan, 2009). As indicated by the diagram below, the relationship and balance of the elements of sustainability are quite clear. Culture is considered as part of the society sector in this diagram. It worth mentioning that economy is much broader than depicted as it also involves: (1) the exchange of services and goods both within and between communities, (2) a focus on the equitable distribution of scarce resources; and (3) maintaining an acceptable level of sustainability.

3 Triple Bottom Line: People, Planet and Profit

The concept of Triple Bottom Line (TBL) extends a business's focus beyond the financial bottom line to include social and environmental factors. It can be considered as measurement criteria of a company's social responsibility, its economic value, and its environmental impact.

This term was introduced in 1998 by John Elkington (Sumeteeprasit, 2014). Later it appeared in the book, "Cannibals with Forks: The Triple Bottom Line of 21st Century Business". According to Elkington, a major challenge of the TBL is the difficulty of measuring the social and environmental bottom lines, which requires having three separate accounts being evaluated using their own specific criteria.

Generally speaking, the bottom line of any company in terms of its income statement is its net income, which is its profit. The TBL is intended to advance the aim of sustainability in business practice, in which companies look beyond profits to include social and environmental issues when measuring the total cost of running the business. In order to maintain sustainability, all businesses need to focus on administrative accounting, financial statements and also net profit (Sumeteeprasit, 2014). The Triple Bottom Line is used as a guideline for business management which includes assessing and reporting business performance in terms of economic, social and environmental factors – internally and externally (Gimenez, Sierra, & Rodon, 2012). The TBL reflects the amount of responsibility a company is taking in terms of affecting environment and society in the course of acquiring profits.

4 Corporate Social Responsibility (CSR)

Corporate Social Responsibility (CSR) within companies and organizations is intended to ensure that all activities are conducted in an ethical manner. This means that organizations and companies need to take into account the social, economic and environmental effects of their actions as well as considering human rights. Therefore, to be able to maintain viability, organizations need to focus on administrative accounting, financial statement, and also net profit (Sumeteeprasit, 2014). Several CSR activities are explained below.

To fulfill their CSR, companies can work in partnership with local communities, make investments in a socially responsible manner (SRI), ensure sustainability and environmental protection, and develop positive relationships with employees and customers.

However, it worth mentioning that the nature of a business' operations will determine the activities it engages in for CSR. Some businesses might focus mainly on social or environmental responsibilities as opposed to others that prioritise their financial goals while attempting to minimise any negative impacts on society or the environment—such businesses are known as Social Enterprises.

5 What Is Green Information Technology (IT)?

The term ‘Green IT’ is not new and has become more popular with time. The term, also known as Green Computing, refers to energy-saving and waste-reducing practices related to the information technology field. With the steady increase in the usage and cost of energy, the amount of waste we are producing is becoming a major concern. This worrying trend is forcing IT departments and sections in each and every business to learn how to deal with this problem in order to reduce the drastic effects on the environment.

Some might ask why we should care about Green IT. The avoidance of Green IT contradicts the reasons for applying CSR and the TBL. In fact, it is impossible to apply these concepts while ignoring the application of Green IT. CSR, the TBL and Green IT must be aligned and work together if they are to succeed and benefit everyone. The manufacture use and disposal of IT devices has significant negative impacts on the environment. IT, especially in regard to the depletion of resources, mining operations, and the waste of resources for the purpose of disposal.

Although IT contributes partially to the issue of increasing energy demands and carbon emissions, the sustainable use of IT is the way to lighten up this dark path. With a combination of social responsibility, smart resource usage, and innovations in the field of technology, Green IT may be able to go some way in addressing several of the issues associated with IT technology, as well as benefiting many sectors, higher education included, by making them more efficient and productive. IT also has a key role to play in the manufacturing and logistics sectors, where it can be used to reduce the amount of energy usage by introducing smart machinery and equipment and facilitating better communication between various sections of the supply chain. Another way to help companies to run more efficient systems is to apply Demand Management and smart meters using interactive real-time energy displays to advise users to use the energy more efficiently.

Several benefits which Green Technology offers (Pinola, 2019) include:

- More efficient use of power
- Waste reduction
- Limiting the use of hazardous materials
- Creation of eco-friendly products
- Sustainability
- Encouraging telecommuting
- Promotion of teleconferencing tools
- Use of cloud-based services and application.

6 Green IT Advantages and Disadvantages

Most of the participants who completed the survey questionnaire for this study are working in the private sector and in the fields of Humanities and Information Technology. Most of the participants have a bachelor's degree, while the group with the second highest number of participants comprised pre-university people. Most of the participants (105 out of 111) use their smartphones to access the Internet. In fact, the Internet has played a major role in familiarising many participants with the concept of Green Technology. For others, these concepts were introduced within their school curriculum.

Surprisingly, all of the participants agreed that changing their tech devices frequently would damage the planet and cause serious damage to the environment; This indicates the level of awareness among young people as well as those with a tertiary education.

The survey findings indicate that increasing awareness is the most important way to change the mindsets of manufacturers and users in regard to the use of technology, with education being rated second as an attitude-changer.

Green IT Advantages

Green Technology can help to reduce toxic gas emissions that contribute to climate change and global warming. Furthermore, it encourages positive competition among businesses in different fields and gives them the chance to compete with each other by introducing more sustainable and environmentally friendly products which entails applying more green procedures and sustainable policies. Moreover by introducing green policies and applying them on a daily basis in business plans, companies would be able to save a huge amount of money which can be invested in more green technologies, especially in new businesses—technologies such as paper-less procedures and renewable energy for electronic devices such as solar and wind power.

Green IT Disadvantages

Similar to many other technologies, Green technology has several disadvantages, some of which are explained below.

As been mentioned earlier, in order to be able to implement procedures and move towards sustainable development, organizations may need additional planning and undertake reforms which can be costly. This might be impossible for businesses and as a consequence, they will find it difficult to compete with larger businesses.

Moreover, there is always a risk of failure to achieve the goals and being unable to meet the green standards. This may cause businesses to lose profits and customers. In addition, the aim of green technology is to deliver services and products aligned with current standards and customer expectations. This can be achieved only if businesses are flexible enough to adapt quickly to changes, or face failure. Many factors need to be considered carefully in regard to the application of green technology to manufacturing. These include product design, product safety, recycling features, efficiency, manufacturing processes, and energy usage, to name a few.

7 Research Methods and Research Question

In this section, an explanation will be given regarding various types of research methodologies, together with reasons for the selected methodology and research approach. The aim of the research will be stated, and the research questions will be formulated. The main research question for this research is: What are the advantages and disadvantages of green IT use in Australia?

The research question is: How can green IT assist businesses to increase profits while using new energy sources to reduce their operations' negative impacts on the planet? Furthermore, the study investigates the ways by which the current mindset can be altered to one that favours sustainable practices. To address the research objective and answer the research question, the research examines the findings related to the importance of awareness and attitude change which are necessary for sustainability, the advantages, disadvantages and risks associated with the shift to a more sustainable society, and ways to prevent or minimize them.

To answer the research question, an online survey was conducted. The data gathered from participants were analysed and the findings provided the basis for conclusions and recommendations. Recently, and more than ever before, businesses and organisations in Australia have begun to adopt sustainable practices, indicating an awareness of green technology in this country. However, some of the survey responses signalled the need for more education and awareness.

Online research is becoming one of the most popular methods used by research for the gathering of data. However, although this approach has several appealing features, it is not without drawbacks (Redline & Dillman, 2003). Both the advantages and disadvantages of online survey research are discussed in this section.

One of the main advantages of the online survey is that it is very low cost compared to the focus group approach or phone interviews. Data collection is easy and simplified data sources makes it simple to analyse and compile collected data. Sample size is an important yet underrated aspect of any kind of research; the online survey ensures an adequate sample which would lead to a more accurate conclusion.

Sample choice can make this research approach prone to errors since assumptions made about the sample might not be accurate. Another disadvantage is the rigidity of the questionnaire since there may be possible responses that are not covered, resulting in missing out on data. Furthermore, there is a difference between self-administered and interviewer-administered surveys (Sanchez & Maria, 1992).

8 Results

The online survey questionnaire items were designed to collect participants' demographic data such as age and education, as well as data about their daily Internet usage, the devices they use for this purpose, their attitudes towards and opinions about sustainability, and the perceived advantages and disadvantages associated with the

Table 1 Respondents in terms of age of range (Prepared by the Author)

Range of ages	Respondents
17 years old and under	0
18–20	16
21–24	14
25–30	24
31–35	14
36–40	15
41–45	5
46–50	8
51–55	6
56–60	5
61–65	4
Over 65	0

adoption of sustainability. The findings addressed the research question and enabled conclusions to be drawn.

The survey was conducted online among 111 participants (response rate: 100%). The survey was distributed via a link provided to participants. However, because some questions were left unanswered, there was the problem of missing data

As shown in Table 1, the largest percentage (21.62%) of respondents belonged to the 25–30 years age group; 13.51% were in the 36–40 range; the two third largest were the 21–24 and 31–35 groups. The lowest numbers were those for over 65 and under 17. This range is depicted in Fig. 1.

As it is illustrated above in Fig. 2, females constituted the majority of participants in this survey at 64.86%.

Although a wide range of occupations were apparent, However, a large number of participants chose the "Other" option. Participants represented a wide range of professional fields: Accounting, Business Law, Information Systems, Information Technology, Computer Science, Management, Marketing, Humanities, Science and Engineering, Art and Design. To be more specific regarding the "Other" options, these included Education, Automotive, Public Service, Student, Education and so on. Table 2 shows that most respondents chose the "Other" field, with a clear majority of 53.15% indicating the private sector as their workplace. Information Technology and Humanities were the fields with the greatest number of respondents at 8.11% and 7.21% respectively.

Table 3 indicates the participants' highest level of education, the highest number (26.13%) having a bachelor's degree, followed by 14.41% with a professional certificate.

Table 4 shows the devices that participants use to access the Internet. A large number of participants (29.83%) use their smart phones to access the Internet, followed by (24.43%) who use, not surprisingly, their laptops. Furthermore, other

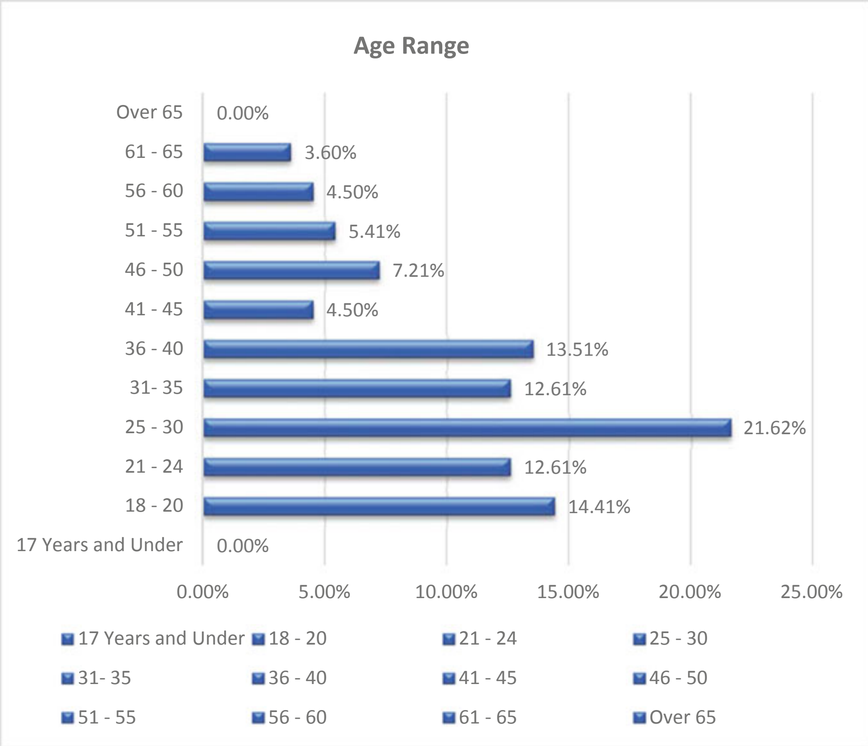

Fig. 1 Age range of participants (Prepared by Author)

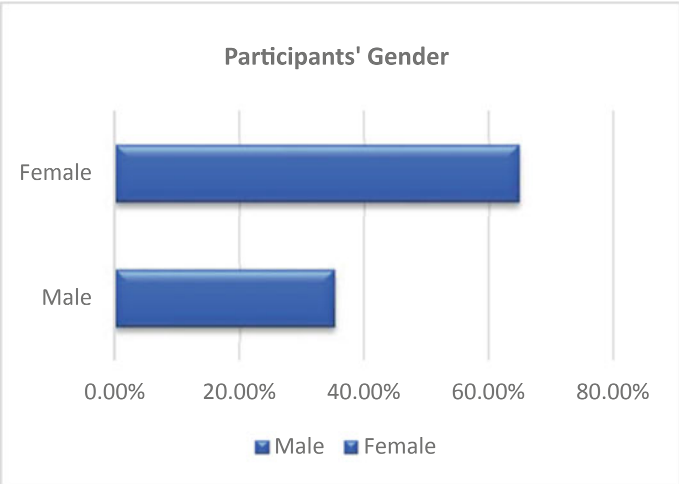

Fig. 2 Gender of survey participants (Prepared by the Author)

Table 2 The participants' main fields of study (Prepared by the Author)

Field of study	Respondents
Accounting	3
Business Law	2
Economics and Finance	0
Information Systems	2
Information Technology	9
Computer Science	1
Management	5
Marketing	2
Health Sciences	5
Humanities	8
Science and Engineering	4
Art and Design	7
Others—Please specify	63

Table 3 Highest level of education (Prepared by the Author)

Education level	Respondents
Primary education	2
Higher secondary/pre-university	26
Professional certificate	16
Diploma	10
Advanced/higher/graduate diploma	4
Bachelor's degree	29
Post graduate diploma	1
Master's degree	8
PHD	2
Others—please specify	13

Table 4 Preferred device for accessing the Internet (Prepared by the Author)

Electronic device	Respondents
Smartphone	105
Laptop	86
Tablet	55
PC	39
Desktop	49
Netbook	5
Workstation	10
Others—please specify	3

Table 5 Means through which respondents were introduced to terms "Sustainability" and "Green Technology" (Prepared by the Author)

Answer	Respondents
School	44
Higher education	26
Internet	59
Books	12
Magazine	9
News media	37
Conferences	2
Others—please specify	8

Table 6 Respondents' beliefs re. damage caused to the planet by frequent changing of devices (Prepared by the Author)

Answer	Respondents
Yes	56
No	13
Maybe	39
Not at all	3

devices such as game consoles and smart tv were included in the "Other" section, which had only 3 (0.85%) responses.

Table 5 shows the means through which participants were first introduced to the concepts of sustainabilityand . Most participants (over 50%) named the Internet, with School (22.34%) and News (18.78%) being second and third respectively. However, some respondents were not at all familiar with these terms. As generally acknowledged, the Internet plays a key role in raising people's awareness of social and other issues as it is the most popular media nowadays. Therefore, any actions related to raising awareness and even the training of users can be performed through the Internet. Conferences, at only 1.02%, contributed the least to raising awareness of sustainability and green technology.

The results shown in Table 6 are very positive, indicating that the majority (50.45%) of participants are totally aware of the environmental damage they are causing by frequently changing their electronic devices. However, although only 3 out of 111 respondents (2.7%) believe that no damage is being done, this indicates the need for education to change people's mindsets and make them more aware of the harm that can be caused by devices.

According to Table 7, respondents believe that Awareness (20.09%), Education (19.86%) and Training (13.55%) are three major means by which the mindsets of both designers and users can be changed in favour of sustainability and green technology. The role of social networking and Internet are also significant in fourth and fifth positions with 16.36% and 14.95% respectively.

Table 7 Ways to change designers' and user's mindset regarding sustainability and green technology (Prepared by the Author)

Answer	Count—percentage (%)
Training	58
Education	85
Awareness	86
Workshop	21
Internet	64
T.V.	43
Social networking	70

Table 8 Types of green IT being used by participants (Prepared by the Author)

Answer	Count—percentage
Virtualization	12
Cloud computing	39
Social networking	82
Smart technology	54
Blockchain	8
Drones	8
Robots	2
IoT (Internet of Things)	5
3D printing	8
AR (Augmented Reality)	2
VR (Virtual Reality)	11
Artificial Intelligence (AI)	8
Big Data	5

Table 8 illustrates the types of green technology adopted by users: Social Networking, Smart Technology and Cloud Computing are in first three spots, respectively at 33.61%, 22.13% and 15.98%. Last were Robots and Augmented Reality, chosen by only two (0.82%).

Cronbach's Alpha is applied to test the reliability and internal consistency of the online survey questions. This is a test commonly used by researchers to examine the validity and accuracy of online survey questions (Gliem & Gliem, 2003).

Following the rules provided by George and Mallery (2003) in regard to Alpha scores:

$\geq 0.9 =$ Excellent
$\geq 0.8 =$ Good
$\geq 0.7 =$ Acceptable
$\geq 0.6 +$ Questionable
$\geq 0.5 =$ Poor
$\leq 0.5 =$ Inacceptable

Furthermore, According to Field (2009, p. 647) KMO values are classified as:
0.5–0.7 = Mediocre
0.7–0.8 = Good
0.8–0.9 = Great
Above 0.9 = Superb.

As shown in Table 9, the result of KMO and Bartlett's test value is 0.915. This value indicates that the data is suitable for factor analysis, and the sample size is acceptable since the value is greater than 0.5. The result of the Bartlett test (0.0000) indicates that the correlation between variables is significant and adequate because the value is <0.5.

As shown in Table 10, the result of the Cronbach's Alpha test is 0.966; therefore, the reliability of Alpha test is assured.

Tables 11 and 12 show an Alpha value of 0.970 and according to information provided at the beginning of this section, it refers to a valid result meaning that the analysis is reliable for this study. The KMO test result is 0.922 and Bartlett's test result is 0.000; just like Awareness, the results for advantages are 'outstanding'.

As shown in Table 13 the Alpha value is 0.955 which means the result for this section of the study is as reliable as others. The values of 0.915 for KMO and 0.000 for Bartlett's test of Sphericity indicate that the outcome and findings of this analysis will be valid and reliable (see Table 14).

Table 9 Results of KMO and Bartlett's test for awareness (Prepared by the Author)

Kaiser-Meyer-Olkin measure of sampling adequacy		0.915
Bartlett's test of sphericity	Approx. Chi-Square	1343.697
	df	78
	Sig.	0.000

Table 10 Cronbach's alpha for awareness (Prepared by the Author)

Cronbach's alpha	No. of items
0.966	23

Table 11 Cronbach's alpha for advantages (Prepared by Author)

Cronbach's alpha	No. of items
0.970	24

Table 12 KMO and Bartlett's test for advantages (Prepared by the Author)

Kaiser-Meyer-Olkin measure of sampling adequacy		0.922
Bartlett's test of sphericity	Approx. Chi-Square	2478.409
	df	276
	Sig.	0.000

Table 13 Cronbach's alpha (risks) (Prepared by the Author)

Cronbach's alpha	No. of items
0.955	13

Table 14 KMO and Bartlett's test for risks (Prepared by the Author)

Kaiser-Meyer-Olkin measure of sampling adequacy		0.915
Bartlett's test of sphericity	Approx. Chi-Square	1343.697
	df	78
	Sig.	0.000

The total variance matrices for awareness, advantages and risks are presented. Each matrix has three components, and since principal component analysis has been conducted on the correlation matrix, the variables have been standardized based on the online survey. In order for minimum variance explained to be acceptable in factor analysis, it has to be at least 60% (Hair et al., 2012).

For Awareness, the total variance for elements 1, 2 and 3 are 8.461, 1.158 and 0.795 respectively as shown below in Table 15 their percentage and cumulative values are given in percentages in front of each one in the row.

Advantages has three elements with high values of 0.866 for the first element, 0.818 for the second one and 0.759 for the last one. Total variance values for these elements are 14.349, 1.489 and 1.001 respectively (see Table 16).

Because only those variables with a value greater than 1 need to be extracted, we have only three components for advantages.

Table 17 shows the three components in Initial Eigenvalues: 8.461 for first component, 1.158 for the second one and 0.795 for the last one. Since factor analysis has been conducted on the correlation matrix, the variables are standardized, which means that each variable has a variance of 1 and the total variance equals the number of variables used for the analysis. Table 18 shows that all three components have a cumulative value of 80.103%.

The rotated Factor Matrix for awareness produced ten variables for factor 1, eight variables for factor 2, and two variables for factor 3. As evident, the three highest

Table 15 Total variance for awareness (Prepared by Author)

Total variance explained					
Component	Initial eigenvalues			Rotation sums of squared loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	8.461	65.083	65.083	8.461	65.083
2	1.158	8.906	73.989	1.158	8.906
3	0.795	6.114	80.103	0.795	6.114
Extraction Method: Principal Component Analysis					

Table 16 Total variance for advantages (Prepared by the Author)

Total variance explained					
Component	Initial eigenvalues			Rotation sums of squared loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	14.349	59.789	59.789	14.349	59.789
2	1.489	6.205	65.994	1.489	6.205
3	1.001	4.170	70.164	1.001	4.170
Extraction Method: Principal Component Analysis.					

Table 17 Total variance for risks (Prepared by the Author)

Total variance explained					
Component	Initial eigenvalues			Rotation sums of squared loadings	
	Total	% of Variance	Cumulative %	Total	% of Variance
1	8.461	65.083	65.083	8.461	65.083
2	1.158	8.906	73.989	1.158	8.906
3	0.795	6.114	80.103	0.795	6.114
Extraction Method: Principal Component Analysis					

values for factor 1 are 0.835, 0.796 and 0.752. Therefore, it can be concluded that most of the participants were aware that sustainability would reduce air pollution and climate warming, and decrease energy consumption (see Table 19).

As Table 20 indicates, most of the participants are aware of the effects of green technology and sustainability on the environment: it can reduce the carbon footprint and noxious emissions and decreases energy consumption. Awareness has a great impact on the application of a new concept such as green technology to daily activities. For the second factor in Awareness, the highest value is 0.833. This generated another new factor (Waste Management) which involves the use of recycled materials as well as the recycling of materials, using renewable materials, and producing less waste. Green software is the last new factor in the Awareness category with characteristics such as "easy to upgrade" and "easy to add software". Participants' responses to items regarding awareness in Australia show a good level of awareness of this issue. However, the importance of education and training has been mentioned as well, which will be discussed further in subsequent sections.

First factor for awareness includes the variables discussed below. Given the areas to which they are linked, all these variables have been categorised under Environmental Sustainability since they all contribute to a sustainable environment. The second factor based on the variables is categorised as Waste Management since the variables concern waste management, reduction of waste, and waste disposal.

Table 18 Factor loading matrix for awareness in (Prepared by the Author)

Rotated component matrix[a]	Component		
	1	2	3
Reduce air pollution	0.848	0.145	0.189
Reduce climate global warming	0.781	0.268	0.183
Reduce diseases and even death of humans	0.698	0.174	0.149
Use less raw materials	0.673	0.400	0.125
Use less energy	0.671	0.517	
Reduce carbon footprint	0.670	0.428	0.261
Sustain environmental standards and rules	0.625	0.452	0.332
Reduce consumption and waste of resources	0.619	0.475	0.255
Use solar energy	0.587	0.484	0.259
Have clean emissions	0.539	0.363	0.361
Are easy to recycle	0.492	0.470	0.477
Use recyclable materials	0.255	0.833	0.285
Use recycled materials	0.206	0.829	0.289
Have good ethical principles	0.413	0.732	0.163
Use renewable materials	0.361	0.717	0.287
Have portability efficiency	0.195	0.659	0.340
Produce less waste and toxins	0.533	0.628	
Have less packaging	0.476	0.599	0.164
Have successful production cycles	0.442	0.582	0.245
Have long life	0.510	0.573	0.208
Shifting the mode of consumption from personal ownership of products to provision of services	0.484	0.488	0.141
Are easy to add new software	0.259	0.225	0.850
Are easy to upgrade	0.167	0.313	0.843

"a" represent both how the variables are weighted for each factor but also the correlation between the variables and the factor

The variables in the last factor clearly relate to specifications for green software, hence the name of the last factor.

As indicated in Table 21, the results of the online survey in regard to advantages show that there is still much room for improvement in regard to sustainability in Australia—environmentally, socially and economically. In the literature review, these three aspects of sustainability were discussed in detail and it was concluded that any green technology should be adopted in all three areas, on which it can have positive effects. The table above shows the positive effects of applying green technology in Australia.

Table 19 New factors for awareness (Prepared by the Author)

Variables	Factor name
Reduce climate global warming	Environmental sustainability
Reduce diseases and even death of humans	
Use less raw materials	
Use less energy	
Reduce carbon footprint	
Sustain environmental standards and rules	
Reduce consumption and waste of resources	
Use recyclable materials	Waste management
Use recycled materials	
Have good ethical principles	
Use renewable materials	
Have portability efficiency	
Produce less waste and toxins	
Are easy to add new software	Green software
Are easy to upgrade	

Table 20 Factor loading matrix for advantages (Prepared by the Author)

Rotated component matrix[a]			
	Components		
	1	2	3
Reduce pollution	0.866	0.144	0.257
Reduce emissions	0.826	0.298	0.182
Reduce health hazards	0.761	0.345	0.213
Reduce carbon footprint	0.746	0.429	0.121
Reduce energy and water usage	0.683	0.265	0.445
Increase green strategy	0.657	0.251	0.452
Reduce raw materials usage	0.603	0.285	0.497
Reduce paper usage	0.572	0.540	0.282
Improve corporate social responsibility	0.561	0.398	0.459
Satisfy customer needs	0.196	0.818	0.315
Create new jobs	0.293	0.762	0.212

"a" represent both how the variables are weighted for each factor but also the correlation between the variables and the factor

Table 21 New factors for advantages (Prepared by the Author)

Variables	Factor name
Reduce pollution	Pollution reduction
Reduce emissions	
Reduce health hazards	
Reduce carbon footprint	
Reduce energy and water usage	
Increase green strategy	Green business
Reduce Raw Materials usage	
Satisfy customer needs	
Create new jobs	
Attract new opportunities	
Attract quality employees	
Reduce risk management	Efficiency
Increase efficiency	
Increase cost-effectiveness	
Improve human rights	
Increase productivity	

Three new factors have been named based on their values and categories in Table 21.

As can be seen in Table 22 the highest value for the first factor of Risks is 0.855, for the second factor it is 0.813, and for the third factor, it is 0.865.

Risks, as indicated in Table 23, are mainly related to social and financial areas. There are eight elements related to social matters; all of these are under a new factor named "Environmental Governance Failure". For the second factor, there is a risk of financial problems such as high costs and higher interest rates. The third factor in this section is linked to regulations and paperwork. Organizations need to focus on avoiding or minimizing these negative impacts on society by having a realistic view of green technology and sustainability. The better such risks are managed, the more productive and effective green technology projects will be, not to mention that it would minimize unhealthy competition among companies and organizations which would not serve all purposes of green technology, one of which is to benefit society.

Table 23 shows that, based on the result of the survey, three different elements are generated, and new names have been allocated to each item according to its category.

9 Discussion, Future Research and Limitations

The survey respondents were mainly female, accounting for 72 of the 111 respondents. For the age range, 21.62% of these respondents were aged between 25 and

Table 22 Loading factor matrix for risks (Prepared by the Author)

Rotated component matrix[a]

	Component		
	1	2	3
Increase security and systems failures caused by environmental problems	0.855	0.266	0.212
Increase transaction failure due to environmental liabilities	0.845	0.211	0.267
Increase scandals by perceived environmental irresponsibility	0.804	0.306	0.209
Increase governance failure (including environmental actions and environmental compliance failures)	0.802	0.339	0.243
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	0.794	0.319	0.280
Increase fraud (including environmental actions and environmental compliance failures)	0.768	0.362	0.156
Increase marketing failure by perceived environmental irresponsibility	0.759	0.444	0.187
Increase interest rates	0.328	0.813	0.258
Increase insurance crises due to environmental disasters	0.393	0.753	0.175
Inflate costs	0.260	0.718	0.425
Increase supply chain crises due to suppliers' environmental problems	0.551	0.641	0.144
Increase competition for and cost of raw materials	0.221	0.234	0.865
Increase number of new regulations including environmental	0.298	0.256	0.824

"a" represent both how the variables are weighted for each factor but also the correlation between the variables and the factor

30, and none of them was under 17 which is understandable given the fact that the target participants for this research were in the workforce. Most of these participants were using their smartphones to access the Internet and the second top option was the laptop.

According to the data, for participants, the Internet was the main source of information about green technology and sustainability. Most of the participants agreed that changing their devices more frequently would cause irreparable damage to the environment. Furthermore, responses indicated that education and awareness were crucial to changing designers' and users' mindset with regard to sustainability and green technology.

Green IT Advantages would encourage citizens to change their mindset, leading to significant positive changes. The demand for green jobs soars, this trend may give businesses the incentive to work on resource efficiency and innovation concepts. A change from fossil fuel to renewable and green alternatives will increase GDP growth since alternative fuel sources have positive impacts on climate change. Hopefully by continuing this trend and mindset, Australia will be able to achieve the goal "Zero-Carbon Electricity Grid" by the end of 2020 (source: https://cpd.org.au/).

By generating and adhering to green IT models, the path to sustainability in the IT industry becomes simple. Any model consists of four different but continuous

Table 23 New factor for risks (Prepared by the Author)

Variables	Factor name
Increase security and systems failures caused by environmental problems	Environmental governance Failure
Increase transaction failure due to environmental liabilities	
Increase scandals by perceived environmental irresponsibility	
Increase governance failure (including environmental actions and environmental compliance failures)	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	
Increase fraud (including environmental actions and environmental compliance failures)	
Increase marketing failure by perceived environmental irresponsibility	
Increase interest rates	Financial escalation
Increase insurance crises due to environmental disasters	
Inflate costs	
Increase supply chain crisis due to suppliers' environmental problems	
Increase competition for and cost of raw materials	Regulation complication
Increase number of new regulations including environmental	

process elements: awareness, translation, comprehension and green IT value. By applying a successful model, the sustainability of the environment is guaranteed.

To be able to accomplish tasks and achieve goals, an adequate budget needs to be allocated. If challenges are not addressed from the outset, organizations and businesses will waste money and could fail. Moreover, inadequate training and education of employees may also lead to failure and unwanted results despite a good plan and a substantial budget allocation.

As discussed earlier, awareness plays a key role in the successful implementation of green technology within society. However, the success of an awareness campaign can be compromised by several factors listed below, which are directly linked to achieving goals and achieving successful implementation of green technology:

– Not having sufficient knowledge regarding environmental sustainability.
– Not having enough knowledge about green technology.
– Having a managerial philosophy based on profit.
– Not being flexible towards required changes.
– Receiving insufficient assistance from government.

These factors can be reduced and managed by identifying and understanding them. Moreover, companies and organizations may need assistance to prepare for such challenges in advance so that they can be managed effectively.

The implementation of a new strategy or approach in the workplace would succeed only if everyone involved is fully aware of and understands the proposed changes. A new project or undertaking has a better chance of succeeding if the people concerned are made aware of its advantages, know who will be involved either globally or locally, and understand how the process of change will be conducted.

An effective awareness campaign should shed light on waste management, green software and environmental sustainability. The survey results indicate that there is a need to raise the awareness of people in Australia in regard to these issues. Only in this way can desired goals be achieved.

Here we summarise the new factors emerging from the online survey. These new factors are grouped according to various categories and are related to different sections. These factors cover areas ranging from financial matters to environment and business procedures. The new factors are listed below.

As Table 24 illustrates, Green Technology can bring advantages to society and business such as environmental sustainability, waste management, green software, pollution reduction, green business and increased efficiency.

Finally, after analysing the acquired data, this research has provided useful and practical information as well as insights on ways to ensure a brighter future for the next generation.

The study results indicated that the implementation of green technology facilitates environmental sustainability, better waste management, and encourages the design of more green software in the market. However, these positive outcomes are not achievable without a change in mindset; this study illustrates that the more successful we become in terms of raising awareness, the better the results would be which include reducing the level of pollution and increasing the level of green business and efficiency.

Furthermore, the disadvantages associated with the implementation of Green IT cannot be ignored. The results of the data analysis indicate that there are several risks, the most prominent being: the failure of environmental governance, an increase in costs, and the introduction of complex laws and regulations.

By being aware of risks, we can guarantee a safer procedure, and a more successful outcome with less financial burden for organizations which in itself would encourage the continuation of a potentially more profitable process.

The research method chosen for this research is quantitative. Data was collected from participants by means of an online survey questionnaire which is one of the most popular instruments using by many researchers. This method, however, has its own limitations.

Sampling: The sample for this research included people in Australia, mainly female and with a bachelor's degree in different fields. Most of the participants were working in private sectors.

Time: The online survey took some time because some participants did not really understand the topic and the aim of the research. Hence, they did not understand its

Table 24 Summary of new factors (Prepared by the Author)

Variables	Factor name
Reduce climate global warming	Environmental Sustainability
Reduce diseases and even death of humans	
Use less raw materials	
Use less energy	
Reduce carbon footprint	
Sustain environmental standards and rules	
Reduce consumption and waste of resources	
Use recyclable materials	Waste management
Use recycled materials	
Have good ethical principles	
Use renewable materials	
Have portability efficiency	
Produce less waste and toxins	
Are easy to add new software	Green software
Are easy to upgrade	
Reduce pollution	Pollution reduction
Reduce emissions	
Reduce health hazards	
Reduce carbon footprint	
Reduce energy and water usage	
Increase green strategy	Green business
Reduce Raw Materials usage	
Satisfy customer needs	
Create new jobs	
Attract new opportunities	
Attract quality employees	
Reduce risk management	Efficiency
Increase efficiency	
Increase cost-effectiveness	
Improve human rights	
Increase productivity	
Increase security and systems failures caused by environmental problems	Environmental governance failure
Increase transaction failure due to environmental liabilities	
Increase scandals by perceived environmental irresponsibility	

(continued)

Table 24 (continued)

Variables	Factor name
Increase governance failure (including environmental actions and environmental compliance failures)	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	
Increase fraud (including environmental actions and environmental compliance failures)	
Increase marketing failure by perceived environmental irresponsibility	
Increase interest rates	Financial escalation
Increase insurance crises due to environmental disasters	
Inflate costs	
Increase supply chain crises due to suppliers' environmental problems	
Increase competition for and cost of raw materials	Regulation complication
Increase number of new regulations including environmental	

importance, and it took longer than expected to receive completed questionnaires from them.

Incomplete Surveys: Because some of the participants tried to answer the questionnaire on their phones, they were not able to see all sections properly, and therefore missed some of the questions. Subsequently, they were asked to complete the survey questionnaire using their laptops or desktop computers.

Although the majority of participants had a substantial amount of knowledge of green technology and the effects of technology on the environment, a significant number of participants responded "Maybe" to the question asking whether changing their devices frequently would have any adverse impact on the environment. This unexpected response signals the need for further research in areas of awareness and much-needed education in Australia to shed more light on all facets of CSR and the concept of sustainability.

In addition, there must be a clear definition of sustainable development to make it easy for all participants to understand the meaning of this term, thereby saving time and confusion so that desired results can be achieved quickly.

10 Conclusion

Although technology has become an inseparable part of most businesses, and organizations are relying more than ever on technology to get the most from their resources, this trend has produced numerous concerns due to the fact that the use of technology is having adverse effects on the environment. Moreover, the exploitation of natural resources is about to leave the next generation without the same resources as ours. Exploitation alongside with the lack of a practical approach for managing e-waste affect the balance of the three pillars of sustainable development: environment, economy and society to be able to maintain this balance, awareness is required leading to a change in mindset. The advantages of green technology need to be publicised, thereby leading to different attitudes and encouraging businesses to adopt a green approach. Moreover, just like any other technology, this one comes with a number of disadvantages, but by being able to identify them, they become easier to handle. If potential disadvantages are recognised and dealt with from the outset, rather than in the middle of green IT implementation, there is more likelihood that the mission will succeed.

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Sustainable Cloud Computing in China

Yuchao Duan, Tomayess Issa, Theodora Issa, and Vanessa Chang

Abstract Cloud computing, which provides computing resources dynamically, is an internet-based computing technology. This paper aims to exam the attitude of higher education sector in China towards the sustainability in the Cloud. Although cloud computing users are now aware of this term, many aspects are still unfamiliar to them. This paper focuses on the sustainability theme. Three factors are associated with sustainability; they are social, financial and environmental. In total, twenty-five interviews were conducted to test participants' attitude towards those factors in order to discover any hidden patterns and correlations among them. Participants were from several different cities in China. From this paper, it can be seen that the awareness of this technology depends on a circumscribed principle—that of 'cost-benefit'. This paper also examines relevant factors to point out the other concerns that potential users should consider before moving to the cloud.

Keywords Cloud computing · Sustainability · China · Society · Finance · Environment

1 Introduction

Cloud computing can be described as a computing resource pool which provides data storage, online applications and other online services. Cloud users can utilise the computing resource based on their needs and requirements with minimal management effort. Several researchers have conducted in-depth studies on sustainable cloud

Y. Duan (✉) · T. Issa · T. Issa · V. Chang
School of Management, Curtin University, Perth, WA, Australia
e-mail: Kevin1986cn@hotmail.com

T. Issa
e-mail: Tomayess.Issa@cbs.curtin.edu.au

T. Issa
e-mail: Theodora.Issa@curtin.edu.au

V. Chang
e-mail: Vanessa.Chang@curtin.edu.au

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but have not closely examined the relationship between sustainability and cloud computing as well as the benefits. This paper provides an overall perspective of cloud computing technology and sustainable development by conducting and analysing interviews. Through direct interaction with interviewees, the researcher can obtain qualitative data. The results from interviews were extremely helpful when refining the initial model and creating questionnaire items as the interview phase provided detailed and in-depth knowledge to the researcher on the research topic.

2 What Is Cloud Computing?

The National Institute of Standards and Technology (NIST) (Mell and Grance 2011) defines cloud computing as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*".

2.1 Cloud Computing Characteristics

One of the most important characteristics of cloud computing is virtualization. The computing, storage and network capacity resources in the cloud are virtualized and can be implemented at various levels including virtual machine and platform levels. For instance, various applications and software can run within different operating systems which are on the same physical machine (Garg and Buyya 2012). Resource pooling is another characteristic. In order to serve multiple consumers, the provider's computing resources are pooled, using a multi-tenant model and dynamically allocating and redistributing different physical and virtual resources based on consumer demand. There is location independence because customers normally have little knowledge in terms of the exact location of the resources provided, but they might be able to specify locations at higher levels of abstraction such as countries, states, or data centers (Mell and Grance 2011). Other major characteristics of cloud computing include their service orientation, loose coupling, strong fault tolerance, business model and ease of use (Gong et al. 2010).

2.2 Service Models

According to the Metz (2011) and NIST definition of cloud computing, there are three different methods of delivering cloud services to end users: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

Software as a service means that an application or software is running on a virtual server which can be accessed from anywhere at any time as long as there is an Internet connection (Cusumano 2010). For instance, Google Calendar and Google Mail are based on the SaaS. The PaaS is another cloud server model which can provide required resources to users in order to create applications and services in the cloud; this means that users no longer need to download or install applications (Qayyum et al. 2011). For instance, the App Engine of Google is a type of PaaS. Storage space, hardware, servers and other devices can be offered by the IaaS platform provider; this equipment can be used directly and the platform provider is responsible for the maintenance tasks (Bhardwaj et al. 2010).

2.3 Deployment Models

Just as cloud services have different models such as SaaS, PaaS and IaaS; there are different deployment models of cloud computing as well. According to Metz (2011), the NIST definition outlines four different deployment models for the cloud: Private cloud; Public cloud; Hybrid cloud; Community cloud. Private cloud is defined as an individual institution operating its own cloud (Metz 2011). According to Wyld (2010), in the private cloud model, the cloud infrastructure is owned solely by a company and it may be managed by the organization or a third party and may exist on the premises or off-premises. Schubert et al. (2010) point out those private clouds are normally operated by the respective organization; the functionalities are not exposed to the customers directly and it is similar to Software as a Service from the customer's perspective. On the other hand, public cloud is a cloud service that is available for use by the general public (Metz 2011). The cloud infrastructure can be accessed by the public cloud users or a large-scale industry group and is owned by the cloud provider (Wyld 2010). Public cloud is based on the standard cloud computing model and the cloud service provider will make resources such as storage space or applications available to the general public cloud computing users through the Internet. The subscription models of public cloud services include a pay-per-usage model or may even be free.

Hybrid cloud allows institutions to deploy an application or system using more than one type of deployment model (Metz 2011). The term "private cloud" refers to a proprietary network or data centre managed by the organization; "public cloud" means that public cloud users can share the cloud infrastructure; the hybrid cloud is maintained by both internal and external providers. According to VMware (Chang et al. 2010), hybrid cloud is a cloud infrastructure consisting of two or more clouds; private and public cloud can be combined together under standardized technology and specific rules that enable application and data portability.

The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise. Schubert et al. (2010) believe that, generally, cloud systems are restricted to the local infrastructure; for instance, public cloud service providers offer their own computing infrastructure to users.

3 Sustainability

Sustainable business approaches help to generate profits by improving business practices, without any negative impact on the global or local environments (Kumar and Vidhyalakshmi 2012).

3.1 Major Drivers of Sustainability

Climate change is one of the greatest threats facing humanity (Kepes 2011). For instance, Air pollution is one of the greatest killers these days as it will impact on human health. In 2015, polluted air was responsible for 6.4 million deaths worldwide, including 4.2 million from ambient air pollution and 2.8 million caused by household air pollution (Landrigan 2017).

It is essential to reduce the carbon footprint in order to decrease the speed of climate change. In 2007, the Information and Communication Technology (ICT) industry was responsible for 2% of the total global carbon emissions (Pettey 2007). Moreover, the carbon emissions from the ICT sector will nearly triple from 2002 to 2020 despite a variety of energy efficiency measures (Smarr 2010). Thus, ICT energy efficiency should be accelerated so that we can use the ICT infrastructure in a smart way in order to reduce global greenhouse gas emissions.

3.2 Social

Good leaders and workers always have the highest impact on the success and sustainability of any business. However, human beings need to be supported by the latest technology tools if they are to contribute their best (Kumar and Vidhyalakshmi 2012). Cloud will be unanimously selected as the best option for IT implementation in business due to its reach in every sphere of all business models.

3.3 Economic

When IT operations are outsourced to cloud, the major benefit is a reduction in staffing costs, and cloud services and its applications such as SaaS save a huge amount of IT infrastructure investment (Kumar and Vidhyalakshmi 2012). A thorough business evaluation should be conducted prior to moving to cloud, for instance, the pay-per-use pattern may not be cost-effective if the IT requirements are mostly stable (Tak et al. 2011).

3.4 Environmental

Using cloud computing for ICT operations not only reduces the cost of operations but also takes care of the environmental issue (Kumar and Vidhyalakshmi 2012, Uchechukwu et al. 2014). According to Amazon's estimations (Hamilton 2009), energy-related expenses amount to 42% of the total amount spent on the purchase and operation of servers (based on a three-year amortisation schedule). Even more critical is the fact that current data centres spend about 60–70% of their total budget just on cooling their ICT equipment (Malone and Belady 2006).

4 Research Method

This research applied Qualitative research method. It is typically utilized for examining the significance of social phenomena (Feilzer 2010). The interviews provided the researcher with detailed and in-depth information on the topic of sustainable cloud computing

4.1 Research Question

What are the factors pertaining to sustainability that should be taken into consideration when developing the new sustainable cloud computing model for the higher education sector in China?

4.2 Qualitative Interviewing

Qualitative interviewing was used to gather information that cannot be obtained using other methods. Surveys might offer mass data about a particular issue, but they lack the depth of understanding that a qualitative interview provides (Tierney and Dilley 2001). Students, staff and IT personnel were interviewed in order to obtain their opinions about and attitudes towards the sustainability in the cloud computing. In terms of the interviews' data analysis, the researcher utilised both manual coding and qualitative research software such as NVivo version 11 which provided a workspace and tools that enable the easy organisation of information. The academic literature on interviewing provides guidelines on the number of interviews that are needed. For instance, McCracken (1988) says eight in-depth interviews are sufficient for marketing and business researches; Warren (2001) believes 20–25 interviews are usually enough; and Spradley (1979) claims a research project might include between 25 and 30 interviews. On the other hand, Glaser (1967) and Johnson (2001) do not recommend a specific number of interviews or observations, but state that the researcher should continue until a state of theoretical saturation is achieved. The number of interviews needed to explore a given research question depends on the nature of that question and the kind or type of knowledge the interviewer seeks.

Thus, for this research, there were 25 interviews with internal stakeholders (students, academic staff and IT personnel) and external stakeholders (service providers and research partners). NVivo version 11 was used to analyse the interview data.

4.3 Interview Data Gathering

Twenty-five interviews were conducted in total. Participants were from three different cities and three different universities. Each interview lasted for approximately 30 min.

4.3.1 Organization Descriptions

Participant organizations involved in this study were coded in order to preserve their anonymity. Participants were from three universities and two cloud service providers. The code "Uni" is used to represent university; each code is followed by "Stu", "Te", "IT" or "Re", which stand for student, teaching staff, IT personnel and researcher, respectively. The code "Csp" stands for cloud service providers, and it followed by "Con", it means consulter. The numbers indicate the interview sequence. For instance, Uni2_IT3 means this participant is the third IT staff member who has been interviewed in the second university. Csp1_Con1 stands for the first interviewee from the first cloud service company.

University Details

Table 1 indicates the details of three different universities and they are coded from Uni1 to Uni3.

Table 1 University details

University code	Established year	Location	The number of the students
Uni1	1956	Inner Mongolia province	Over 20,000 full-time students
Uni2	1956	Beijing	Over 10,000 full-time students
Uni3	1958	Guangzhou	Over 10,000 full-time students

Cloud Service Provider 1 (Csp1)

Csp1 is located in the Inner Mongolia province and focuses on building public IT infrastructure, supporting the application of government, public service, and industrial informatization. Csp1 adopts the methods of "corporate investment, government support, commercial operation, and industrial linkage" to construct and operate, and plans to implement it in accordance with the principles of "overall planning and step-by-step implementation". The calculation capacity of Csp1 reaches 500 trillion times/second and the storage capacity reaches the PB (petabyte) level. Csp1 provides data storage service, disaster recovery, the cloud technology applications, and promotes the development of green IT.

Cloud Service Provider 2 (Csp2)

With fifteen years of research and development in the field of high performance computing, Csp2 has mastered a range of cloud computing core technologies and products including cloud infrastructure, cloud management platform, cloud security, cloud storage, and cloud services. Csp 2 provides end-to-end cloud computing solutions for users. With the increasing number of information centre equipment, the energy consumption of data centres attracted more attention in the recent years, and green energy has become more and more important to society. Csp2 has an integrated data centre infrastructure solution that includes a variety of infrastructure products and related services. With their solution, the energy consumption of the data centre can be greatly reduced.

4.3.2 Interviewees

As can be seen in the Table 2, seven students and seven university staff members were interviewed. The number of IT personnel interviewees is one less than student and

Table 2 Occupations of interview participants

Interviews	Total number of interviews with **Consulter**	Total number of interviews with **IT personnel**	Total number of interviews with **Researcher**	Total number of interviews with **Teaching Staff**	Total number of interviews with **Student**
	4	8	2	5	6
Total number of interviewees	**25**				

staff. The number of service providers and research partners who have participated in this phase are three and two respectively.

4.3.3 Interview Preparation

The first step of the interview phase was the design of the interview questions. Based on the literature review, a series of questions was proposed and discussed with the researcher's supervisors; all the questions were related to the research topic and initial model. Questions were designed to reflect the initial model, and to contain governance, sustainability and performance management aspects. The final version of the interview questions was then submitted to Curtin University Human Research Ethics Committee which subsequently granted ethics approval.

4.3.4 Conducting the Interview

Participants were contacted via email, phone or WeChat software first to confirm their availability, interview location and time. Interviews were conducted either face-to-face or online. However, some participants preferred to have more time to prepare their answers or wanted to write down their answers rather than talk to the researcher face-to-face. Hence, the questions were sent to them and the answers were later returned to the researcher.

4.4 Data Preparation

The interview data was documented in Microsoft Word format for the purpose of analysis. NVivo version 11, which is a qualitative data analysis computer software package produced by QSR International, was utilised to analyse the interview data.

4.5 Data Analyses

Thematic analysis was applied to the interview data. Qualitative data analysis involves "Decontextualisation" and "Recontextualisation" (Tesch 1990). "Decontextualisation" enables portions of the topic to be extracted and examined more closely, together with various components of the qualitative data related to similar issues. "Recontextualisation" will ensure that the patterns still concur with the context from which they were gathered, and is critical to avert reductionism (Malterud 2001). Bengtsson (2016) points out that the qualitative data should be analysed in four stages. Stage 1 is "Decontextualisation", in which the meaningful units are identified. In this research, the transcripts of interviews are inputted into NVivo data analysis software (version 11) and meaningful contents are identified. Stage 2 is "Recontextualisation", which is a process that extracts content from its original context. The next stage is "Categorisation", where content is placed into classes in order to identify homogeneous groups. The final stage is "Compilation" which comprises a summary of realistic conclusions by assembling information collected from the interview.

5 Interview Content Analyses

Data from interview was analysed by Nivivo version 11 and the outcomes are shown as below.

5.1 Social Effects

Most participants believe that cloud computing will make people's lives easier. For instance, customers can use mobile applications to order food online; all the details about those restaurants are stored on cloud rather than mobile phones. Speech recognition technologies like Siri increase the efficiency of communication with smart devices. Csp2_Con1 said, "*Cloud users can also save data, personal or work data to the cloud; many people are now using iPhone and iCloud service and upload photos to the Apple cloud service. The maintenance of computing assets is simplified; users do not have to worry about operation and maintenance anymore, because cloud provider has professional operation and maintenance operations personnel. It can also shift the way that people interacting with others*". Another aspect is education, since cloud enables students to access learning resources from different locations, anywhere at any time.

On the other hand, some social concerns emerge with the development of cloud computing. Everything has two sides. For example, regarding the smart phone, people spend too much time on it nowadays for online chatting, and gaming. Traditional businesses will be driven out of the market. Eventually, the software industry will disappear because of cloud computing since most of the applications will be online-based apps with extended modules or functions. Perhaps PCs, even laptops, will disappear as people need only a display device to perform different tasks online.

Another risk is the security or privacy issue because the data is on cloud and there is a chance that data may be hacked. Moreover, the copyright issue should not be ignored. One example is Baidu cloud, one of the most popular cloud-based file backup and data sharing platforms. People can share music and movies on the cloud. Luckily, the government has noticed that and now the Baidu cloud has been regulated and most of the pirated music and movies have been removed.

5.2 Financial Effect

Most of the interviewees agree that cloud computing would save money. Cloud users only have to pay for the actual use, for instance, the amount of storage or resources they have used.

Another financial benefit is flexibility. If customers need extra computing power, they can choose the additional or add-on services and applications. Small-scale companies will especially benefit from this feature. When starting a new business, they have limited budget and may not be able to afford having a server room or other essential computing resources in some cases. Thus, it might be a good idea to start with renting a few servers from a cloud service provider to meet the current requirements, and then they can add extra services as the business grows in the future. In other words, the on-demand payment method will help cloud users to save a lot of money, as they do not have to buy hardware and software. Sometimes, the financial benefit of cloud computing is long-term. Based on the requirements, the set-up fee may vary in different cases. It may take a long time to recoup the cloud investment made initially.

From a university's perspective, cloud computing has the ability to reduce the IT operation budget dramatically. For instance, instead of hosting the official website in-house, the cloud provider can host it in the cloud; hence, the school's operations expenditure will decrease as there is no need to purchase hardware and software for maintenance. Moreover, students and teaching staff can save money in terms of learning and teaching. Uni1_Te1said, "*E-book is getting popular these days and it is normally cheaper than a printed book*".

With the development of cloud infrastructure, cloud pricing is decreasing. Cloud computing is more affordable than before, and customers have more options these days as many new cloud providers enter into this market. For instance, Huawei came into this area recently.

Overall, the majority of interviewees believe that cloud computing could reduce expenditure on computing hardware and software as all the services are available online. If companies use an in-house IT infrastructure, they need to invest substantial amounts on servers, hardware and software in order to provide computing services. With cloud computing, companies pay only for what they have used. Cloud computing also saves energy. This means saving on electricity as well as on software and hardware.

Moreover, for cloud users, this technology could save money by reducing the number of IT staff. From the cloud users' perspective, especially for small scale organizations, it is not necessary to have an IT department to manage the IT resources, as computing tasks could be completed online. They can literally put all data in the cloud, and the cloud service provider will take care of the data. As a result of the competition, cloud service fees are becoming much cheaper these days. Cloud computing can bring financial benefits for both users and cloud providers.

Users can save money on hardware purchase, software development and other things, while cloud providers will obtain financial profit from the users, enabling them to improve their services. So, if everything goes well, users and providers are both winners. On the other hand, training costs should be taken into consideration. When adopting a new technology, the organization needs to train the staff first.

5.3 Environmental Effect

Most participants agreed that cloud computing could save power, decrease CO2 emissions. Csp1_Con1 pointed out "*if we can save energy, we save the environment*". ICT energy consumption is one cause of pollution, but cloud computing is eco-friendly and cost-saving. It will be a good start to move to cloud because cloud computing is part of green IT, and moving to cloud is going green. Nowadays, the general public care about the environment and they want to reduce pollution. Centralization is one of the advantages of cloud computing. Everything is in the resource pool, thereby minimizing the negative environmental effects of ICT; hence, cloud computing has positive effects on the environment. Centralization technology can reduce energy consumption and less energy consumption means fewer trees will be cut down, so the environment performance of ICT will be improved. In other words, centralisation and virtualization are the two most important characteristics of cloud computing, and they are both helpful for our environment by reducing the carbon footprint.

On the other hand, some participants believe that the environmental effects of ICT have been overrated. According to Uni3_IT2, "*nowadays, more and more companies are using cloud computing, but the environment in some places is getting worse. There are many things can affect the environment, including car exhaust, factory pollution. Compare with those factors, computing just use very few energy*". Because there are too many sources of pollution, even though cloud computing may become widely used in the future, nothing will change.

Another question raised by a participant is that if people use providers' computing resources, energy can be saved on users' side, but what about the providers' side? The more users they have, the more energy they will use.

5.4 Meaning of Sustainability

Sustainability itself is a very broad topic. It is linked to development. In order to improve the ecological environment, resources must be used more efficiently, and there should be some coordination between humans and nature. According to Uni2_Re1, "*Sustainability is not simply equivalent to environmental protection, it consists three aspects, Ecological, social aspect and Economic aspect. So the first one ecological, we need to minimize the environmental damage, we need to be eco-friendly. Secondly, we need to need human's needs, sustainable development doesn't require all of us to go back to primitive society, but we need to protect the environment, to raise the society awareness. Lastly, profit is important, we need to find the balance, to keep the organization running and to protect the environment in the same time*".

Most participants believe that economic development and environment protection should be taken into consideration at the same time. In other words, saving or making money should go hand-in-hand with saving energy and protecting our world, and doing no harm to the environment. Economic development should be eco-friendly and should attempt to reduce pollution. Other key words mentioned by respondents in relation to sustainability include "energy", "recycle" and "business performance". Uni1_IT4 mentioned that "*it is also about the balance between environment protection and origination's growth. The environment needs to be protected. On the other hand, companies need profit, so the balance between environment protection and economic development is important. Simply put, not only the environment, but also the organizations' profits need to be protected, because naturally, a company needs profit to survey. If the company could not feed itself, how could they protect the environment*"?

From the perspective of a cloud computing service provider, cloud users of small and medium size organizations do not have to make significant changes in terms of cloud infrastructure in a long period of time once they purchase cloud computing or IT resources, or they do not have to change many IT components to the current infrastructure, because changing the infrastructure cloud lead to many potential issues. For instance, if an organization upgrades the hardware, the applications running on the previous hardware may not be compatible with the new hardware. Csp2_Con1 pointed out that "*cloud computing service provider will provide computing resources, so customers do not need to know what is the underlying hardware running at the back, all they can see is just computing resources, like how may gig bite CPU/RAM. However, the customers or the cloud users need to care is how much gig bite RAM they need. In other words, the beauty of virtualization is that the users do not have to worry about the underlying hardware, and all the resources are integrated by provider*".

A cloud computing service provider can do better than on-premises IT in terms of carbon emission reduction, because energy consumption is relevant to centralisation, distribution, production, disposal of hardware etc., and the service provider optimises the management of hardware selection and disposal. When the service providers centralise the computing resources, they consume less power, which means less electricity consumption. This means less pollution. Cloud computing activities could also reduce electronic device waste; this is another benefit of centralisation.

Traditional computing consumes an exorbitant amount of energy for cooling the servers. Some participants pointed out that service provider should not waste the heat from the cloud servers or hosts. Perhaps they could collect and store the heat and use it to heat water and buildings in winter, which is an excellent approach to saving energy. Since the energy consumption from the cloud service provider can decrease, the price of the cloud may be cheaper.

Uni1_Te2 mentioned that "*the environmental problem becoming a major issue in China, the air quality is getting worth, haze everywhere especially in winter. So, while developing the economy, general public needs to pay attention to environmental protection, protect it for next generation*". This means that responsible development will be able to meet the needs of the current generation, while ensuring that the needs of future generations will also be met. Cloud computing or sustainable computing will help to achieve this.

Although most participants agree that sustainability will help to ensure a healthy relationship among people, resources and the environment, and that people need to protect the environment, some participants admitted that they do not care too much about the environmental aspect of cloud computing. According to Csp2_Con1, when promoting the service to customers, "*saving cost must be the priority of marketing practices*".

5.5 Summary of the Interview Outcome

This paper contained an in-depth discussion of the interviews. The data was collected from twenty-five participants comprising service providers, IT personnel, researchers, teaching staff and students, most of whom have experience using cloud computing technology. The purpose of this research is to identify the factors pertaining to sustainability and to have a better understanding of cloud-related concepts.

Overall, the social, economic and environmental effects should be taken into consideration when developing sustainable cloud computing. Although the majority cloud users are already familiar with the term 'sustainability' and agree that we should protect the environment, most participants would still consider the financial effect first. Before adopting any new technology, it is human nature to ask "how much could we save by using this technology", and this is a reasonable concern. If a company wants to survive in a competitive market, it needs to think about the profit. That is why many researchers are trying to prove the financial benefits of cloud computing. In the future, more companies will come to realise this and move to the cloud in order to reduce the carbon footprint.

However, the limitation of this research is that social, economic and environmental factors are too broad or not stated precisely enough. Therefore, further research is needed in the future in order to specify the most relevant sub-factors for each main factor.

6 Future Directions and Conclusion

In conclusion, cloud computing is helpful in terms of reducing the carbon footprint by centralising computing resources. Social, economic and environmental effects are the factors pertaining to sustainability that should be taken into consideration when developing the new sustainable cloud computing model for the higher education sector in China. Therefore, the research question is answered. In the future, we need to improve the general public's awareness of sustainability. For service providers, "eco-friendly" could be a feature of their services or a promotional slogan. We need to keep everything running but we should not harm the environment. That is why we need more new technologies and new ideas. Last but not the least, economic growth, social responsibility and environment are all important, and we should not ignore the environmental impact that modern technologies have.

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Australian Users' Perspective of Green Blockchain Technology Adoption in Businesses

Aman Mahajan and Tomayess Issa

Abstract In this research, our aim is to understand Australia's perception of how Blockchain Technology can provide sustainability to businesses today and whether, therefore, it can be considered as Green Technology. This research will determine the relationship between Blockchain Technology and sustainability by perusing the relevant literature and will examine this relationship by analyzing the gathered survey responses. This research will also help readers to understand the business advantages and challenges associated with Blockchain Technology. Firstly, this paper presents the history of sustainability and explores the current knowledge about this concept. This is followed by an introduction to Corporate Social Responsibility (CSR) that looks at what it is, why it is important, what types and roles it entails, and the positive and negative factors associated with it. Further, the Triple Bottom Line (TBL) concept is introduced and explained. The concept of Green IT is discussed and evaluated for its effectiveness in helping organisations become energy efficient and making their surroundings greener and carbon-less. Then, Blockchain Technology is defined in detail: its types, how it works, smart contracts, advantages and disadvantages are discussed in depth. Additionally, the implementation of Blockchain Technology in different industries is discussed, giving an insight into the ways that Blockchain Technology can bring sustainability to businesses and hence can be considered as Green IT. Moreover, apart from the evaluation of the relationship between sustainability and Blockchain Technology found in the literature, we analyse the online survey data, applying the principal component analysis via IBM SPSS Statistics 25 software that offers more insights and accurate results. The survey was completed by 101 respondents in Australia who hold academic degrees, and the analysed survey data generated various factors for business advantages and challenges. The most important business advantages that an organisation could achieve with Blockchain Technology were improved TBL, a reduction in resource consumption, and better

A. Mahajan (✉) · T. Issa
School of Management, Curtin University, Perth, WA, Australia
e-mail: amanmahajan1987@gmail.com

T. Issa
e-mail: Tomayess.Issa@cbs.curtin.edu.au

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‘green’ practices. However, blockchain technology faces several challenges associated with strict governance and environmental compliances. Finally, this paper acknowledges the limitations of the research and suggests future research advantages. The research questions regarding the relationship between Blockchain Technology and sustainability will be answered. Additionally, recommendations are offered, and conclusion are drawn. It is anticipated that this research and its findings are intended will benefit public and private organisations, relevant researchers and other individuals who have an interest in Blockchain Technology as a sustainable technology, and in exploring the potential of Blockchain Technology in different industries.

Keywords Green blockchain · Green IT · Awareness · Advantages · Challenges · Australia

1 Introduction

At present, in regard to all business domains, a major concern is how they can achieve sustainability in their operations, products, and business processes. With the growing public concern regarding sustainability, greener practices, and supporting a healthy environment, most companies are achieving sustainability by helping communities globally and locally, customers, stakeholders, and shareholders by means of a set of activities mentioned in their corporate social responsibility (CSR) documents. These activities are intended to help societies and the environment while simultaneously ensuring profits for their shareholders as well as achieving the 3Ps of the Triple Bottom Line (TBL) concept: People, Planet and Profit. Moreover, IT companies are achieving sustainability by applying Green Technologies in their operations to reduce their consumption of energy thereby decreasing their environmental impact. Nowadays, every enterprise has an IT department that gives it a competitive edge in the market, indicating that technology plays a vital role in today’s business environment. If implemented appropriately, technology can be used to achieve sustainability and a greener environment. In this paper, it is argued that Blockchain Technology is a technology that can help organisations to achieve sustainability while at the same time ensuring customer satisfaction and business profitability. However, most of the academic literature examines Blockchain Technology only in terms of its application in the finance sector (FinTech). However, as shown by our research, Blockchain Technology has vast and as-yet-undiscovered potential which can offer numerous advantages to an organisation: it can encourage growth, increase profits, and contribute to creating to a sustainable environment for the community. Blockchain Technology was introduced in 2008 when the famous cryptocurrency Bitcoin, introduced by Satoshi Nakamoto, used this technology as the backbone for transactions and to store all the transaction data in a decentralised and secure manner. Since then, all the known cryptocurrencies such as Bitcoin, Ethereum and Altcoins, use this technology to manage and store their data in a secure, chronological, and explicit manner. Moreover, Blockchain technology has contributed to developments in the Financial Technology (FinTech) field, and this has encouraged the adoption of this technology in other business domains. Industries including logistics, supply chain, energy, medical, food, music, gaming, and others have invested in this technology to benefit their business and their customers. Although much research is has been conducted on Blockchain Technology, the general public has very limited awareness of Blockchain Technology being a Green IT or sustainable technology (Giungato et al., 2017). Therefore, this research has been undertaken to determine Australia's opinions of Blockchain Technology and whether it has the potential to create a sustainable environment collectively benefiting organisations, the environment, and communities. Hence, this research will help readers to understand Green IT, sustainability, CSR and how Blockchain Technology can help organisations to save energy and contribute to a sustainable environment. In later sections, this understanding will be validated through the various factors which can project Blockchain Technology as a Green Technology, with its associated business advantages and challenges.

2 What Is Green IT?

In today's world, technology is changing daily and advancing rapidly; hence, it can be applied in every domain. Although technological developments are generally welcome as they can assist humans and non-humans in many ways, they can also have adverse effects on the natural environment and environmental sustainability (Murugesan, 2008; Patón-Romero et al., 2017). Every day our planet is subjected to human-generated problems as well as to natural occurrences over which humans have no control. In countries worldwide, people and their governments have come to realize that they need to reconsider their activities and plan to change their ways to save natural resources and the planet as a whole (Jenkin et al., 2011; Patón-Romero et al., 2017). Patón-Romero et al. (2017) stated that the European Union in their Circular Economy Action Plan (Union, 2014) claimed that the Information Technology (IT) field has the biggest impact on the planet's environment.

IT infrastructure, from hardware and software to servers, consumes a great deal of power and emits huge amounts of carbon emissions which increase greenhouse gases (Murugesan, 2008). Kavathatzopoulos (2015), Murugesan (2008) suggested that the impact on the environment is not only due to IT infrastructure but also to the disposal activities of IT (e-waste). Although IT is negatively impacting the environment, advancements in this field can slow down or even reverse the damage (Deng et al., 2017). Cited in Deng et al. (2017), Fuchs (2008), Patrignani and Whitehouse (2015) mentioned that, when researchers discovered that IT can act as an enabler to save the environment, the term 'Green IT' gained importance among researchers, particularly when it was found that Green IT can help businesses and organisations to become energy efficient, thereby reducing their carbon emissions and contributing to the safeguarding of the environment.

According to Cai et al. (2013) and Murugesan (2008), Green IT implies that there should be minimal impact on the environment when creating, manufacturing, using and disposing of the IT hardware such as servers, computer systems, and associated hardware.

Faucheux and Nicolaï (2011) define Green IT as IT activities that have less negative impact on the environment as they leave less carbon footprint. On the other hand, Jenkin et al. (2011) describe Green IT as the utilisation of IT equipment in an energy-efficient way.

Molla et al. (2008) define Green IT as the application of environmental sustainability norms to reduce waste and improve energy saving. These norms include the use of green technologies, pollution reduction, and product maintenance/management for the creation, manufacture, sourcing, use, and discarding of IT-related hardware, software and services.

Green IT involves green technologies such as virtualization, cloud computing, social networking, drones, robots, the Internet of Things, and Artificial Intelligence which can help organisations to solve IT environment-related issues like energy consumption, e-waste and carbon emission (Deng et al., 2017; Elliot, 2011). These technologies provide numerous advantages such as a reduction in carbon emissions and energy consumption, water and paper usage, and the enhancement of both the organisation's reputation and its CSR initiatives. Furthermore, Murugesan and Gangadharan (2012) suggest that Green IT can change the mindset of the general public, employees, and organisations, and can help organisations to create an environment which is sustainable and greener.

2.1 What Is Blockchain?

The Global Financial Crisis occurred in 2008. This incident was an eye-opener, demonstrating that people cannot completely trust banks, government authorities, or any other centralised entity to protect their money, data or information which is centralised, managed and controlled by these trusted entities. Blockchain technology is the solution to these trust-related problems because it is a unique system that has a completely decentralised environment. This means that two parties can interact with each other without having to share their data or information with any third parties. Blockchain technology is the fourth industrial revolution as it has made, and will continue to make, a huge impact on a nation's monetary system, business operations (cited in Chen et al., 2018; Chung and Kim, 2016), and every domain where its implementation could be useful.

Before 2017, Blockchain technology was not popular and only a few people were using it. However, when the price of Bitcoin, the very first cryptocurrency that used Blockchain technology for its implementation, increased to its maximum amount, people started understanding it and realised that it had been running safely and uninterrupted for a decade. This created trust in the technology and interest in its implementation, not only in the cryptocurrency area, but in other sectors including retail, education and health (Collins, 2016).

According to Tschorsch and Scheuermann (2016) and Yli-Huumo et al. (2016), Blockchain is a digital, decentralised, and scattered technology which consists of a network of nodes (computers) which record all completed transactions that have ever occurred in chronological order in a peer-to-peer network. Similarly, Verma and Garg (2017) described Blockchain as a peer-to-peer technology which records information shared between the parties in a legitimate and immutable way. They also mentioned that once the record is entered into the Blockchain network, it is secured through encryption algorithms. The information is secure because no one, including the owner of the block, can change the information stored in the block. This encryption technique in Blockchain has encouraged people to trust this technology.

2.1.1 Types of Blockchain

There are three major types of Blockchain, namely public, consortium and private. Although the differences between these chains is small, they are significant enough to make each one distinctive.

- **Public Blockchain**, as the name suggests, is for the public, so anyone can join the network, be a node, participate in the consensus algorithm, and maintain the ledger. A public Blockchain is open to all, which means that anyone can join, participate and view the transactions occurring on the network (Buterin, 2015; Jayachandran, 2017). In this kind of Blockchain, to keep the users motivated and encouraged, every time the miner mines the block correctly, s/he is rewarded by Bitcoin (Jayachandran, 2017). Examples of public Blockchains are Bitcoin and Ethereum.
- **Consortium Blockchain**, also known as 'federated blockchain' is defined by Buterin (2015) as a network which does not allow anyone to join the network and participate in the consensus process. The viewing of this Blockchain may be public or restricted depending on the consortium policies. This kind of Blockchain has a particular set of nodes which will participate in the consensus process and a transaction becomes valid only if the desired number have reached consensus. Examples of consortium Blockchains include R3 (Banks), EWF (Energy) and B3i (Insurance).
- **Private Blockchain**, also known as permission Blockchain, is a network which is strictly access-controlled and only legitimate users who are invited to join the network can participate and view the transactions. Buterin (2015) and Jayachandran (2017) added that this access layer is set up by the company in order to limit their network's accessibility to only selected users and only these users can maintain the Blockchain in a decentralised manner.

Blockchain technology was used to implement the first-ever cryptocurrency, Bitcoin. Hence, an explanation of the flow of cryptocurrency transaction in the blockchain network will help in understanding Blockchain technology. User A wants to conduct a transaction with user B on a blockchain network. Every user has a pair of public and private keys which can be used to verify the identity of the users on the network and this is done to make sure that the transaction is originating from a legitimate user(s). Once the identities of both users are verified, this transaction is broadcast throughout the network and reaches all the nodes, or miners, for verification and validation purposes. Once the miners solve the complex cryptographic equations associated with this transaction, the miner who solved the equation sends the result to all miners and asks for their consensus. If more than 50% of the miners agree with the transaction and the result, this transaction becomes a block and this new block is added to the existing blockchain, and all the existing nodes or miners update their respective blockchain ledgers. This process of adding a block to the existing chain gave Blockchain its name (Chen et al., 2018; Cocco et al., 2017; Dong et al., 2018; Yli-Huumo et al., 2016). Crosby et al. (2016) and Tschorsch and Scheuermann (2016) added that this newly-created block contains a timestamp, transaction amount, hash value, previous block hash value, and other transaction information. All these blocks are joined with these hash values which are encrypted using the strong hash functions. If any change is made to any of the blocks, it will change the hash and ultimately end up corrupting the entire blockchain; because of this, the blockchain is a secure and trusted public record keeper or ledger.

Smart contracts or digital contracts are the terms and conditions or a protocol present on a blockchain network that help maintain the integrity of the data. They are executed automatically when the desired conditions are met (Verma and Garg, 2017); then, the data is shared in a transparent way. Nofer et al. (2017) added that Smart contracts replace the ‘middleman’, and facilitate data exchange only after certain conditions have been met. Szabo (1997) coined the term ‘smart contracts’ in 1997. Although this technology faced implementation challenges at that time, nowadays, most blockchains are using smart contracts. One example explained by (Buterin, 2014; cited in Nofer et al., 2017) is the Ethereum blockchain that has smart contracts which are executed when there is an exchange of funds between the parties. If the conditions are met, the funds are exchanged; otherwise, the funds go back to the source party. Moreover, by using smart contracts, ownership of crucial documents such as a user’s house documents, land documents, shares, etc. can be maintained on the blockchain.

Having understood Blockchain technology, people have also realised its potential and the beauty of this technology. Today, many companies have started using Blockchain technology and others are contemplating its adoption.

The foremost advantage of Blockchain technology is **Transparency**. Blockchain technology is transparent in nature which means that anyone who has an active Internet connection can view the transactions occurring within a public blockchain network. In the case of a private blockchain, only users with valid credentials can view the transactions occurring on the private blockchain network. Hooper (2018), and Verma and Garg (2017) added that blockchain is a distributed ledger, so every node on the network shares the same information at the same time, thereby creating transparency and trust. Therefore, the information on the blockchain is always accurate and updated.

The second advantage is **Security**. The transactions/blocks in the blockchain network are added only when more than 50% of the nodes agree and give their consensus. Moreover, all information inside each block is encrypted and all the information is distributed across the network so there is no centralised server (Hooper, 2018), making it very difficult for a hacker to break the chain. In the event that a hacker decodes the hash of one block, the hash value of the other blocks in the network must also be changed; this is a very cumbersome task because it requires a lot of computational power to make changes throughout the entire network (Chen et al., 2018; Verma and Garg, 2017). This advantage of blockchain maintains the integrity of the information.

The third advantage is the **Traceability**. Since the blockchain records every transaction in a new block and no overriding is allowed on a blockchain network, this allows the user to track the information from its origin (Hooper, 2018). If A sold his land to B, B sold to C and so forth, until the landowner is G. Each transaction in a blockchain has a block, so should A claim he owns the land, G can show all the transactions recorded on the blockchain from the origin, thereby resolving the issue. This advantage enables logistics companies to track the source of any item and in turn provide information about the source of the item to its customer.

The fourth advantage as explained by Hooper (2018), and the reason for most of the hype surrounding Blockchain, is its **decentralised** nature. The automated machine process of adding new blocks via consensus and distributing them to all the nodes is what makes the blockchain decentralised and eliminates the need for a mediator. This saves time and money since no third party is being relied upon to preserve data.

The French philosopher, Voltaire, stated that with great power comes great responsibility. The same can be applied to technology because, with great technology like Blockchain, which is still evolving, come unavoidable disadvantages. Though the potential advantages of Blockchain are greater than the risks, these risks must still be taken into consideration when businesses adopt blockchain technology. Hence, prior to implementation, the risks must be considered and addressed in order to eliminate, or at least mitigate, them.

The first drawback of blockchain technology is its **huge energy consumption**. Whenever the encryption of a block takes place to provide security and verify that the transaction is from a valid user, a large amount of computational power is required to perform the mining process in order for the block to be added to the network (Marr, 2018; Verma and Garg, 2017). This computational power consumes a great deal of energy, making it costly and harming the environment through its carbon emissions.

A significant drawback is the lack of **government regulation** owing to Blockchain's decentralised nature; for instance, there is no centralised authority to monitor forgery cases (Marr, 2018). Osterrieder et al. (2017) and Web (2018) mentioned that firms or any person who wants to use Blockchain technology must understand that the activity conducted using blockchain could be processed in a different country. This could create some issues or legal actions, and since there is no government, legal body or other centralised authorities involved, the person or firm has to tackle the issue alone.

Another risk is **privacy** since blockchain is a distributed ledger which means that the information in the block could be anywhere, albeit encrypted. Whenever the block which has the encrypted information is processed in the blockchain, the information is distributed to different servers and this may create a risk of privacy loss (Swan, 2015; Web, 2018). Although the information is secured using strong encryption techniques, this privacy risk may hamper the implementation of the blockchain in some nations.

The final drawback is that it is not **easy to use or understand**. The Bitcoin API (Application Programming Interface) which is required by the developer to create any service on the blockchain, is prohibitively cumbersome and difficult to understand (Swan, 2015). This causes great difficulties in implementing it, forcing people to abandon the technology.

However, Blockchain technology has more advantages than disadvantages, enabling businesses to increase their profits. Blockchain technology is not limited to just the FinTech domain, but has the potential to be implemented in various industries, and can-do wonders for business if the aforementioned risks are anticipated and handled effectively.

Blockchain technology is emerging rapidly and several companies are using it in domains such as supply chain logistics, Fintech, and the energy sector and realizing business benefits. However, it still remains that the commercial presence of the blockchain technology is limited to only a few domains because of certain challenges that prevent the more widespread adoption of this technology. This demonstrates that there is a need for greater education and awareness about Blockchain in various areas, namely design, safety, manufacturing and energy, recycling, and social. Improved awareness of Blockchain technology will help clarify how it has greater potential than other technologies, and therefore can offer organisations the opportunity to stand out from their competitors.

Furthermore, Blockchain technology offers several advantages that can assist organisations to achieve sustainability and realise greater benefits for their business and shareholders, thus achieving the 3Ps of the Triple Bottom Line.

The financial advantages offered by Blockchain Technology can help organisations to minimise paperwork and reduce energy consumption, enabling them to achieve greater efficiency in their operations and save on operation costs. The brand and reputation, human resources and shareholders, and environmental advantages can help organisations to stand out from others and thus improve their reputation in the market. Good market reputation attracts greater investments which can be used for various CSR activities and advancements of the business and shareholders and beyond to the community, thereby achieving the TBL.

Because of the challenges that blockchain technology poses, such as risk of failure and prohibitive cost, many organisations are not able to implement it. Since Blockchain technology eliminates the middlemen, many government organisations are against the use of this technology. Further, although the information remains safe and secure in the blockchain, the user interface which is required to access the blockchain may encounter security issues, which may cause a breach of privacy. Moreover, Blockchain technology requires a lot of computing power to keep its network robust and tamper-proof, which causes harm to the environment. Lastly, organisations and governments must devise new business processes and regulations so that this technology can be safely used in any business domain. However, this in turn may lead to an increase in the prices of products.

Although blockchain has significant disadvantages, several of its advantages make it a considerably useful technology of the future. Blockchain comprises features such as decentralisation, encryption algorithms and more, which makes it significant and has created a spark among the different industries, who are interested to see what the technology can offer them. Besides the cryptocurrency industry, Blockchain can be implemented in many other areas, some of which are discussed below.

In the **insurance industry**, blockchain can be used for **asset management and claims processing**. For instance, assets can be registered on the blockchain with their associated information such as details of the asset, owner details, purchase date and time etc. Later, when there is a request for claim processing, the insurer can easily check every detail about the owner and the assets on the blockchain which is immutable and uses strong encryption techniques, Thus, the insurance company can retrieve and validate information ranging from details of assets to customer details. If the details are legitimate, the claim can be processed promptly (Blockgeeks, 2017; Crosby et al., 2016). The blockchain can help insurance companies to not only maintain the assets details but also to protect themselves from fraudulent claims.

Everledger is a diamond company which maintains details about diamonds such as the diamond size, weight, color, and more, in addition to the transaction history of the diamond purchased. All the information is securely stored on blockchain using encryption techniques. Everledger allows the details to be viewed by registered insurance companies, claimants, owners, and government agencies. However, other functions like creating and updating are limited to specific users (Crosby et al., 2016).

In the **Notary** industry, blockchain can be used to check the legitimacy of documents and ensures the privacy of the documents. Services like proof of ownership (to whom a document belongs), proof of existence (document validity) and proof of integrity (the document is genuine and has not been modified or recreated) all use cryptography. Blockchain technology ensures the privacy of the document and removes the need for a middleman, agency or centralised authority for the verification process, thereby saving people's notary fees (Crosby et al., 2016).

Block Notary is a mobile app for iPhone users which allows the user to create proof of the existence of their files such as photos, or any media, using a Bitcoin network (Crosby et al., 2016).

Blockchain can be used in the **music industry**, which is complex as it involves issues related to the inappropriate distribution of royalties among the different contributors to a work, such as artists, songwriter, lyricists etc., due to the abundance of music applications which allow users to listen to music and even to download it completely free (Blockgeeks, 2017; Crosby et al., 2016). There has been a strong call from the music industry to have a transparent system so that royalties can be distributed evenly. Blockchain, combined with a smart contract, can circumvent this problem. According to Blockgeeks (2017) and Crosby et al. (2016), the information about the ownership of the song will be stored in a publicly distributed database (i.e.

a public blockchain) and the distribution of loyalties to each member will be stored in the smart contracts. The smart contracts are executed when the conditions stipulated in them for the executed transaction in the blockchain are met. This enables the royalties to be distributed as specified without any difficulties. This would prevent the uneven distribution of royalties among the different members associated with particular works in the music industry.

Crosby et al. (2016) explained that Blockchain can be used in the **Internet of Things (IoT)** to develop a decentralised IoT. In the IoT, all the data collected by the sensors or devices are stored in one centralised location called a 'hub' and then the hub controls the interactions between the devices or sensors. For instance, if a device wants to exchange data between its attached components, then the interaction with the hub is not required but, currently, cannot be avoided. Hence, the need to implement the new concept known as 'decentralised IoT'. This can be achieved using a Blockchain. The Blockchain's decentralised nature allows devices or sensors to store the data/messages securely on the blockchain enabling them to exchange the messages on the decentralised blockchain.

With Samsung's help, IBM has developed a platform called ADEPT. ADEPT stands for Autonomous Decentralised Peer to Peer Telemetry and uses Bitcoin's decentralised blockchain to allow the devices to send messages securely (Crosby et al., 2016).

Bureau (2017) explained how Blockchain can be used in the **supply chain network** to resolve the traceability issues. The status, source, name, processing location, storage location and other details regarding the product can be stored in the blockchain. For instance, Walmart uses the blockchain to track sales of pork in China. It is easy for a company to track its sales because everything is stored in the blockchain and in the case of a product recall, the company can use the blockchain to locate the affected batches.

The frequently-changing working environment has brought advancements in technology, increasing firms' profits and competitiveness but at the same time having adverse impacts on our environment and the planet's natural resources (Dao et al., 2011). As stated by Hilty et al. (2006), Kavathatzopoulos (2015), Köhler and Erdmann (2004), Mishra et al. (2014), and O'Neill (2010), technology is the biggest consumer of electricity and has a destructive impact on the environment. Conversely, Deng et al. (2017) argued that technology can help reduce greenhouse gas emissions, e-waste and other adverse impacts on the environment. The quest to achieve a sustainable environment can be achieved with the help of Blockchain Technology. It can help firms to maintain a balance between the social, environmental, and economic elements of the TBL (Giungato et al., 2017), thereby facilitating firms to provide a sustainable environment. According to Dabbs (2017), Harrison (2018) and Rossow (2018), Blockchain Technology has the potential to develop clean energy which will be easy to access, and cost-effective, thus enabling people to have a sustainable environment, and helping organisations to achieve sustainability. The potential applications of the blockchain technology can be utilised by different fields aside from the FinTech domain. These benefits can help organisations to achieve sustainability and to give several advantages to themselves and their consumers.

When green energy or renewable energy is created using solar panels, governments or independent authorities check the produced electricity and then issue a certificate called a Renewable Energy Certificate (REC) to the producer which states that the produced electricity is green. After this, the trading price of the produced green energy is negotiated and it becomes tradable and can be purchased by the consumer who desires green energy (Keshav, 2018; Redding, 2018). Currently, the process of issuing a REC to a producer is cumbersome, time-consuming and costly and since this process involves human intervention, there is a considerable chance of errors and fraud occurring (Harrison, 2018; Keshav, 2018; Redding, 2018).

According to Keshav (2018) and Redding (2018), Blockchain Technology is the solution that can be implemented in the solar energy field to replace the centralised authority required to authorise and price the produced green energy. This will reduce the cost of certificates and eliminate fraud and human error.

The Blockchain technology will work in conjunction with the solar panel that will produce the green energy and is connected to the smart meter. This smart meter will issue the REC for the saved energy and store it in the blockchain. Then the transaction will be recorded in the blockchain if a consumer buys the REC. Since every recorded transaction on the blockchain is non-editable, the same unit of generated green energy cannot be sold again (Keshav, 2018; Redding, 2018), thereby reducing fraud and increasing trust. Moreover, there will be no need for a centralised authority to issue the certificate. This reduces middlemen costs and helps the small-scale green energy producers to participate in the market, thus making more green energy available and contributing to a more sustainable environment. Keshav (2018) gave the examples of PowerLedger in Australia and LO3 energy in Brooklyn- USA, that use Blockchain technology to store the REC and the transaction is recorded in the blockchain when the REC is sold.

ElectriCChain uses blockchain technology to provide tokens, namely solar coins, to the green energy producers (Dabbs, 2017). In another example given by Harrison (2018), SunExchange uses blockchain technology to install solar panels in sun-drenched countries like South Africa where people cannot buy the solar panels for their own home. Instead, people buy some cells or solar panels and then these cells are installed on the top of buildings. The electricity produced through these cells is distributed among the local community and the member who purchased these cells is rewarded with Bitcoin.

In today's world where people are cautious about their health and only buy food which is prepared ethically, Bureau (2017), Dabbs (2017), Thinkers (2017) suggested that big companies which have a global supply chain operation with ingredients that come from different parts of the world must make sure that each ingredient is produced and shipped to them properly. Bureau (2017) and Thinkers (2017) explained that transparency is essential in supply chain networks as it ensures that the product information mentioned on the product is legitimate. As blockchain technology has a transparent nature and enables the supply chain to become transparent, this will help companies and consumers alike.

Lab (2017) explained how Blockchain will work in supply chain networks. Every product has a unique serial number and this, along with other required details, are entered into the immutable blockchain. Product information starting from the first point (producer details) to its destination (store shelves) can all be included in the stored data. Hence, Blockchain facilitates transparency as consumers can see all the information relevant to their product from source to destination. One example is Provenance, a company that uses Blockchain technology to make the supply chain transparent and assure consumers that they are buying ethically sourced products.

3 Research Questions and Method

For this research, primary research questions and objectives are formulated and will be answered in subsequent sections. These will guide the research process to ensure that the research is worthy, valid, and valuable for the readers. The questions are: What are the means by which individuals and businesses can be made aware of green blockchain technologies? What advantages can green blockchain technology offer to businesses, and what are its challenges?

A web-based survey, as explained by Archer (2003), is a means of gathering information through a predetermined set of questions disseminated on the Internet. He added that a web-based survey has a certain form and includes a covering letter and hyperlink to the survey. White (2014) further suggested that a web-based survey is a means of collecting information or knowledge about a topic from several individuals. White (2014) also mentioned that this method captures accurate sentiments of the respondents, thus leading to precise results. Singh et al. (2009) state that a web-based survey consists of a set of questions that are delivered to respondents through an online medium. They added that the researcher has to circulate this survey to a large audience or population in order to obtain appropriate samples from the target audience. Several studies (Issa, 2013; Sekaran and Bougie, 2016) state an online survey includes questions prepared beforehand that are sent to the respondents whose answers are subsequently recorded. Issa (2013) mentioned that if the researcher already knows what s/he desires from the research and knows the technique that will be used to measure variables of interest, then an online survey is the best method for gathering data for the study. Issa (2013) explained that an online survey has several advantages; for instance, it takes less time to develop and is therefore less expensive, and it is more environmentally friendly. However, online surveys can also face challenges such as technical glitches, privacy issues and the potential for harm to an individual, ethically speaking.

Research design as stated by Marshall and Rossman (2014) provides a strategy to the researcher that allows the research to be developed and conducted in a logical way. This ensures that the research will address the study issues and the research questions in a coherent manner. Kothari (2004) defined research design as the sequential steps starting from how the researcher will proceed with the study, to the gathering, evaluation and analysis of the data, and ensures that the researcher addresses the research questions effectively. Alternatively, Glanville (1999) suggested that the research design is the plan, which includes examining of the research in a manner so that the research questions or hypotheses can be answered and in addition to this, a researcher must be aware of the various research designs as every study requires different research design.

The research questions were addressed using the survey research method which gives access to a large number of respondents, allowing the collection of ample data which ensures that results and conclusions have a higher degree of accuracy. The survey questionnaire consisted of three parts. The items in the first part pertained to respondents' demographic information such as gender, age, job title, educational information, and employment. The section also included items related to respondents' IT usage, awareness of sustainability and Green IT, and the control factors of Green IT. The second part of the survey questionnaire consisted of 23 statements intended to determine the respondents' awareness of green technology factors; the respondents' responses were captured using the 5-point Likert scale. The third part of the survey questionnaire consisted of 37 statements used to determine the respondents' awareness of the advantages and disadvantages of the adoption of Blockchain Technology in business. Again, responses were indicated on a 5-point Likert scale. The responses helped the researcher to gain knowledge about Australia's view of Blockchain Technology, Green IT and how Blockchain Technology can enable businesses to achieve sustainability.

For this research, the target population was confined to respondents in Australia residing in different parts of the country and working in various sectors. The survey questionnaire was sent to 101 respondents using the Qualtrics survey software. Responses were saved in the Qualtrics database and later analysed with the IBM SPSS Statistics 25 software. This enabled the researcher to acquire a broader and more in-depth understanding of the survey data. The completed questionnaires were submitted by a wide variety of people, ensuring the representativeness of the sample. The completion of the survey was entirely voluntary, and although there was a restricted time frame of one week, respondents were invited to answer the survey questions when convenient.

Reliability, according to Golafshani (2003) and Joppe (2000) is the degree to which the results that are gathered from the study and the selected dataset generate a stable result over a defined period of time. Joppe (2000), and Wainer and Braun (2013) defined validity as being whether or not the research results answer the research questions. They added that the main aim of reliability and validity are first, to determine whether the research result can be reproduced at the same given period of time and, second, whether the research results shed light on or resolve the issue at hand. The reliability and validity have been maintained at different points in this research., Qualtrics survey software was used to record the respondents' answers and IBM SPSS Statistics 25 software was used for data analysis, thus evaluating the reliability and validity of the data.

4 Study Results

The researcher's main motive for conducting this research study was to understand the factors that would label Blockchain Technology as a sustainable and Green Technology. Another aim of this research was to determine the extent to which the Australian public is aware of Blockchain Technology, Green IT, and the advantages and disadvantages of Blockchain Technology in business. The response rate for the online survey questionnaire was 100% (101 respondents) which meant that the in-depth data analysis could proceed, and that precise and accurate results could be obtained, enabling the drawing of valid conclusions.

Figure 1 clearly displays the distribution of respondents according to gender. The total sample size was 101 individuals, out of which 52% were female and 48% were male.

Figure 2 displays the distribution of respondents according to age. As evident, no respondents under 18 or over 65 years of age. The majority (23) of respondents were aged between 25 and 30; only 5 respondents were in the 18–20 age category. From Fig. 2, it can also be deduced that the majority of the respondent's ages were between 25 and 50.

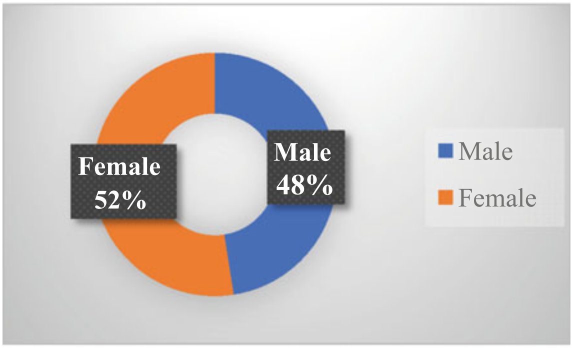

Fig. 1 Respondent distribution by gender

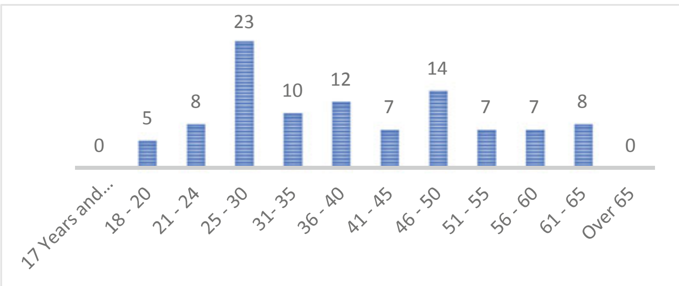

Fig. 2 Respondent distribution by age

Below, Figs. 3 and 4 show the job titles of the respondents and their major field of study respectively. The respondents are from a range of areas and include accountants, students, teachers, CTOs, CFOs, and Blockchain developers, as well as others. Of the 101 respondents, 25 named science and engineering as their major field of study. The remainder were from the areas of information systems and technology, computer science, business law, and accountancy etc. Figure 4 shows that only two of the respondents chose marketing as their major field of study.

Figure 5 is an organisation pie chart, which shows that out of 101 respondents, 59 are in the private sector and 42 are in public sector organisations.

Figure 6 shows that 29 respondents are studying for a master's degree, and 18 respondents are studying for a bachelor's degree, 13 respondents are pursuing pre-university and professional certificates and 12 respondents are pursuing a diploma.

Figure 7 shows that most of the respondents access the Internet using their smartphones, followed by laptop, PCs, desktops and tablets respectively.

When respondents were asked which source(s) gave them an understanding of the concept of sustainability and Green IT, 56 respondents answered that they were able to find information about sustainability and Green IT through the Internet, as shown in Fig. 8. Other major sources were respondents' higher education, and the news media.

Figure 9 shows that 47 respondents believed that the frequent changing of devices can cause harm to the planet. Twenty-one respondents thought that this would not cause harm to the planet. Whereas, 29 respondents were unsure about whether the frequent changing of devices would cause harm to the planet. Four respondents did not think that frequent changing of devices would harm the planet, indicating the need for making people aware of the effect of disposed devices on the environment.

The survey asked respondents to suggest the means by which the public could be motivated to adopt sustainability. Figure 10 shows that awareness followed by education, training, TV and social networking are the means by which the public can be motivated to adopt the sustainability concept. The least recommended medium is a workshop to motivate people toward sustainability, which recorded only 33 responses.

Figure 11 shows that the Australian respondents are using green technologies quite well. The green technology which most of the respondents enjoying using is social networking which recorded 66 responses. The other green technologies which are commonly being used are smart technology, cloud computing, IoT, VR, drones, robots, and virtualisation which recorded 37, 39, 17, 14, 10, 11, 13 respectively. The least utilised green technologies are AI and AR which recorded only eight responses each.

To measure the appropriateness of the collected survey data and to address the research questions in Sect. 3 through the survey responses, Cronbach's Alpha, Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity were applied to the data. These methods were used to check the reliability of the survey responses, so it is essential to understand these tests and their purposes. According to Helms et al. (2006), Cronbach's Alpha measures the internal consistency or reliability of the questionnaire

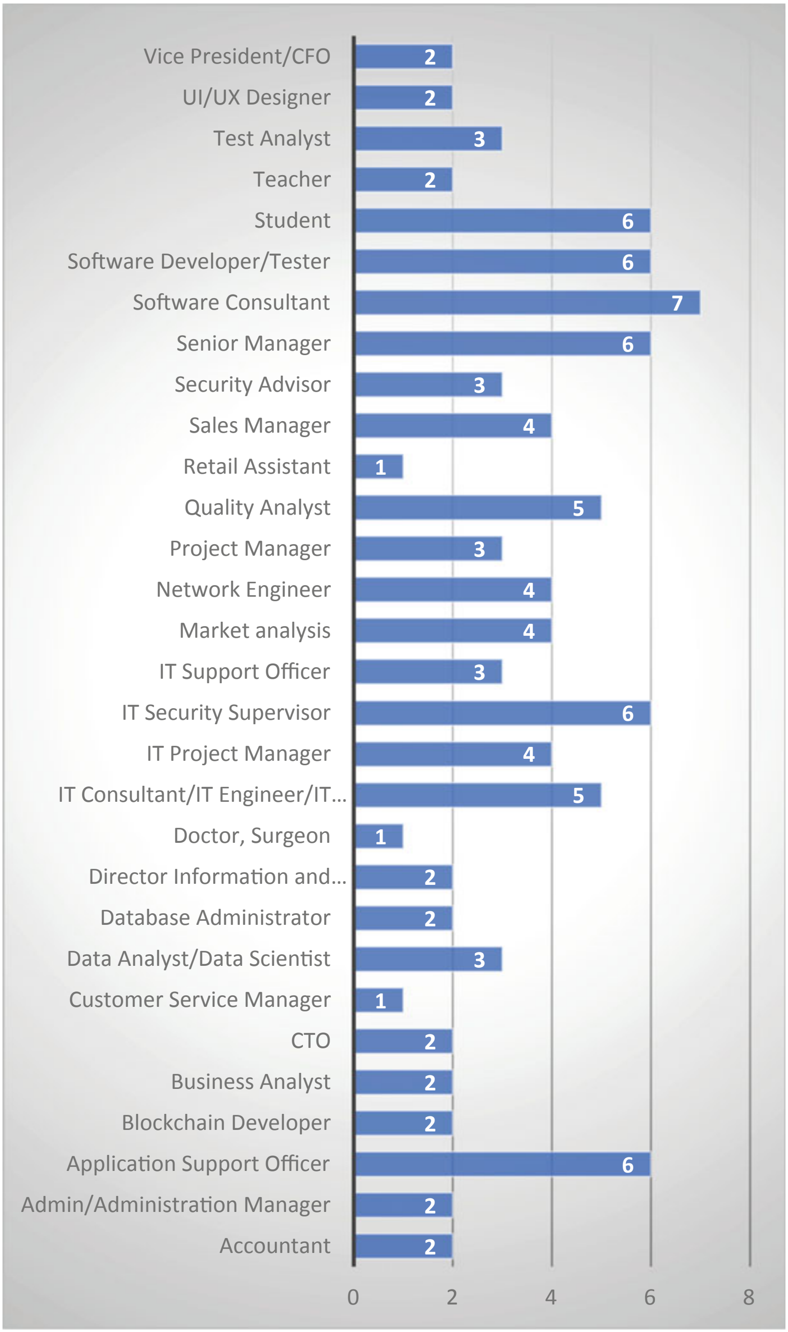

Fig. 3 Respondents' job titles

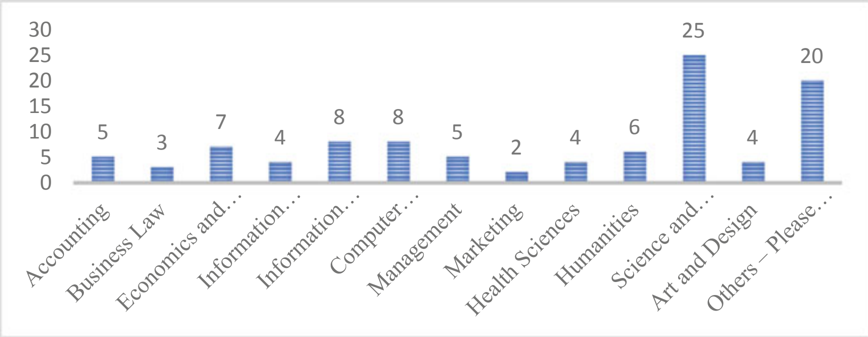

Fig. 4 Respondents' major areas of study

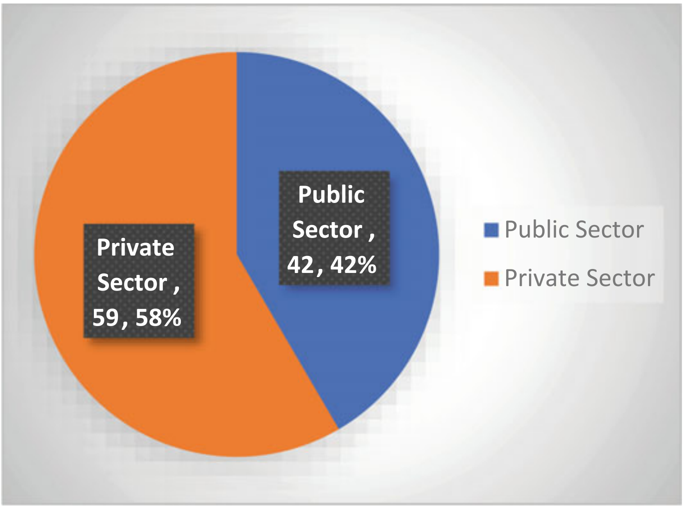

Fig. 5 Respondents' organisation sector

items. Gliem and Gliem (2003) stated that Cronbach's Alpha is the most effective method when using the Likert scale approach because a researcher can devise multiple statements for the same theory for which the Cronbach's Alpha value can be deduced; hence, this value can suggest whether or not the data will be reliable. Helms et al. (2006) suggested that Cronbach's Alpha generates a value and if that value falls below .70, this suggests that there is some issue with the survey items. If the value falls between .70 and .79 then it is considered as acceptable. Values between .80 and .89 are considered as good and values greater than .90 are considered excellent. On the other hand, Kaiser-Meyer-Olkin (KMO) as defined by Hill (2011) and Williams et al. (2010) as a measure used to evaluate the collected data to establish whether this collected data can be analysed using the factor analysis method. KMO yields

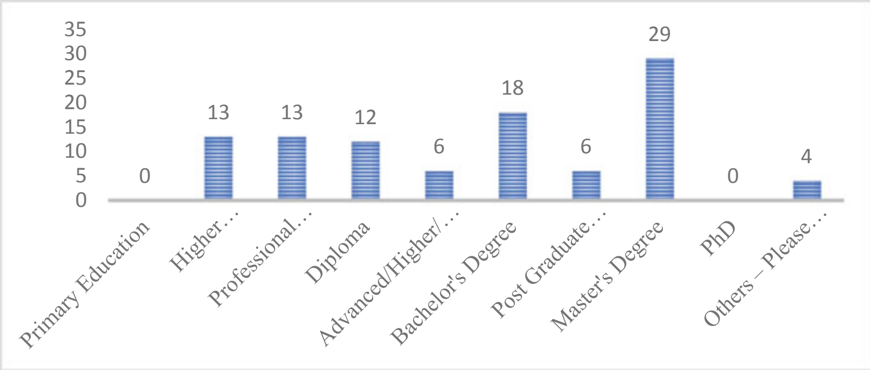

Fig. 6 Respondents' education level

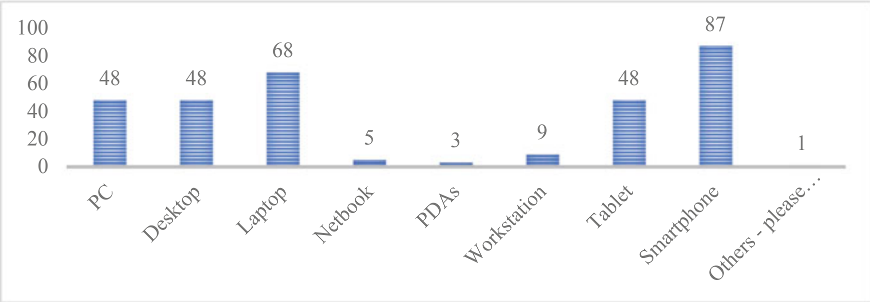

Fig. 7 Devices used by respondents to access the internet (Respondents were asked to choose more than one option)

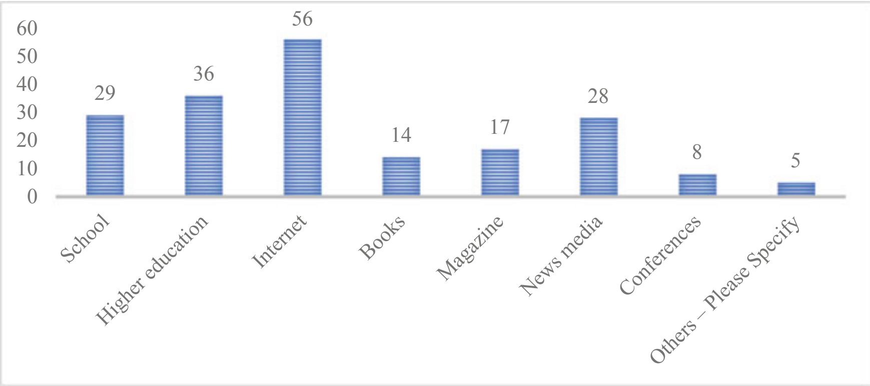

Fig. 8 Respondents' sources of information about sustainability and green IT (Respondents were asked to choose more than one option)

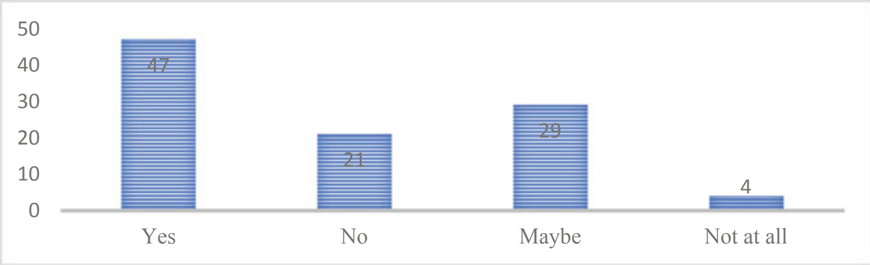

Fig. 9 Respondents' beliefs about the frequent change of the devices (Respondents were asked to choose more than one option)

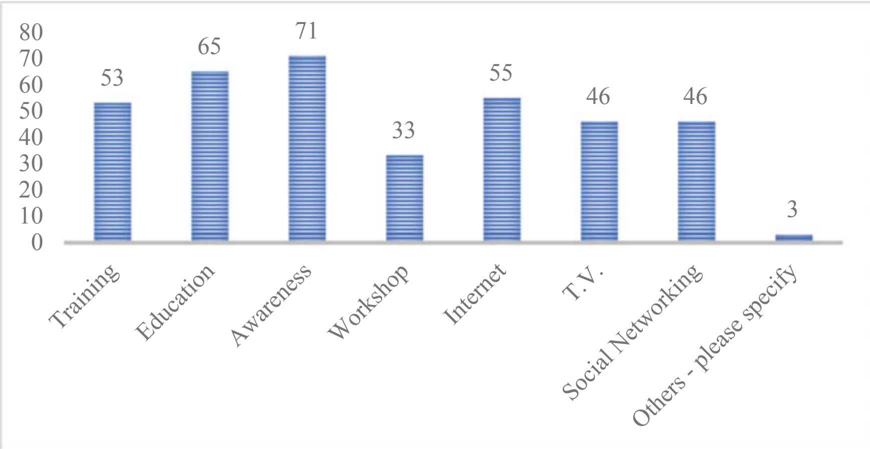

Fig. 10 Respondents' recommended means for changing designers' and users' attitudes in favour of sustainability and green IT

a value between 0 and 1 where a value <.6 is considered as poor and a correction in the data is required whereas a value greater than >.6 is considered acceptable. If the KMO value ranges between .7 and .79, it is considered as average, KMO values ranging between .8 and .89 are considered as commendable, and KMO values above .9 are considered as outstanding. Similarly, Bartlett's Test (BT) as defined by Hair et al. (2006) is a method used for the evaluation of the collected data to determine whether it is suitable for factor analysis.

The Cronbach's Alpha, Kaiser-Meyer-Olkin, and Bartlett's Test values for all combined users' awareness of the Green Blockchain Technology factors, all combined Blockchain Technology business advantages and challenges factors, theme-related Green Blockchain awareness factors, and factors for theme-related advantages and challenges were calculated using the IBM SPSS Statistics 25. The Cronbach's Alpha value Green Blockchain Technology awareness factors and all

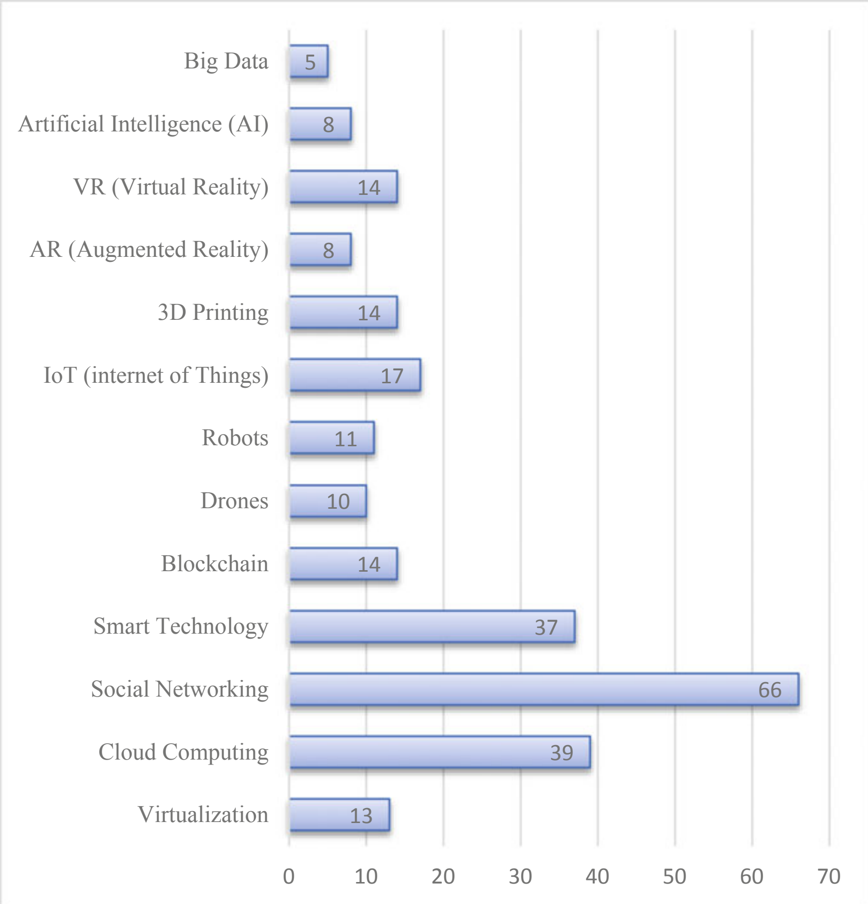

Fig. 11 Green technologies used by the respondents'

combined advantages and challenges factors yielded values of .970 and .968 respectively. Cronbach's Alpha values for each theme for awareness and advantages and challenges, are greater than .70, which means that the collected survey data is consistent and reliable.

Moreover, the KMO value for users' awareness, advantages and challenges associated with Green Blockchain Technology are .918, .933 and .939 respectively. The KMO values for each theme related to factors for awareness, advantages and challenges are greater than .70. Bartlett's test values for users' awareness, advantages and challenges associated with the Green Blockchain Technology are less than .000. Therefore, the KMO and BT results indicate that the collected data is appropriate for factor analysis and therefore can address the research questions (Preacher and Briggs, 2001; Tobias and Carlson, 1969) (Table 1).

Table 1 Cronbach's alpha, KMO and bartlett's test results for users' awareness, advantages and challenges toward the green blockchain technology

Themes	Cronbach's alpha	KMO	Bartlett's test
Awareness	.970	.918	$X^2 = 2067.781$, df = 253, p < .000
Advantages	.977	.933	$X^2 = 2641.230$, df = 276, p < .000
Challenges	.964	.939	$X^2 = 1287.953$, df = 78, p < .000

Table 2 Total variance for user's awareness of the green blockchain technology factor

Total variance explained						
Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	13.883	60.359	60.359	6.465	28.109	28.109
2	1.265	5.499	65.858	5.185	22.545	50.654
3	.877	3.814	69.672	4.374	19.019	69.672

Extraction method: Principal component analysis

After establishing the validity of the collected data, exploratory factor analysis was performed using the IBM SPSS Statistics 25 software. The extraction and rotation method used for analysing the data was Principal Component Analysis and Varimax with Kaiser Normalisation individually. Factor analysis resulted in the total variance as shown in Table 2. This table shows that the eigenvalues for the combined awareness factors have resulted in three factors; the significant factor has an eigenvalue of 13.883 and the least significant factor has an eigenvalue of .887.

To obtain more insights from the collected data, a rotated factor matrix for all combined factors under the users' awareness of the green Blockchain technology factor was developed. Table 3 shows that the factors with values greater than .60 have been combined to find new factors emerging from the responses indicating users' awareness of green Blockchain Technologies.

Table 4 shows the new factors for Blockchain Technology awareness that emerged from the survey responses. New factors for awareness of Blockchain Technology are: Ecological concerns, Environmental materials, and Ethical values.

Furthermore, the advantages of Blockchain Technology were examined via the SPSS software to generate the total variance explained and rotated component matrix for the advantages theme. Table 5 shows three factors generated for the advantages theme. The rotation produced a total of 74.860% of the variation from this group. Table 6 shows the three new factors generated for the advantages of green blockchain technology from the Australian perspective.

Table 7 displays the new advantages that can be obtained by an organisation using Blockchain Technology namely, 3Rs, Triple Bottom Line and new potentialities

Furthermore, the challenges associated with the Blockchain Technology were examined via the SPSS software to generate the total variance explained and rotated component matrix for the advantages theme. Table 8 shows that two new factors

Table 3 Rotated Factor Matrix for all factors under the users' awareness of the Green Blockchain Technology factor

Rotated Component Matrix[a]			
	Component		
	1	2	3
Reduce air pollution	.767	.197	.354
Reduce carbon footprint	.722	.303	.230
Reduce consumption and waste of resources	.712	.459	.183
Reduce climate global warming	.700	.442	.252
Use recyclable materials	.673	.339	.338
Reduce diseases and even death of humans	.658	.125	.481
Sustain environmental standards and rules	.586	.279	.480
Are easy to upgrade	.581	.466	.215
Produce less waste and toxins	.581	.449	.329
Are easy to recycle	.554	.485	.191
Are easy to add new software	.553	.436	.316
Have less packaging	.159	.748	.444
Use renewable materials	.544	.670	.185
Have clean emissions	.291	.658	.440
Use recycled materials	.547	.644	.178
Use less raw materials	.311	.617	.353
Use less energy	.486	.615	.255
Use solar energy	.434	.530	.300
Have long life	.482	.518	.414

(continued)

Table 3 (continued)

Shifting the mode of consumption from personal ownership of products to provision of services	.226	.277	.805
Have portability efficiency	.252	.314	.794
Have good ethical principles	.431	.204	.752
Have successful production cycles	.289	.462	.693

were generated for the challenges. The rotation produced a total of 76.577% of the variation from this group. Table 9 shows two new factors generated for the advantages of green blockchain technology from the Australian perspective.

Table 10 lists the new challenge factors associated with Green Blockchain technology, indicated that an increase in scandals and increased governance were the major challenges facing the adoption of Green Blockchain technology in Australia. Therefore, businesses and government should work together to minimize these challenges to the implementation of this technology so that businesses can become more sustainable.

5 Discussion and New Findings

At present, people across the globe are adopting favourable attitudes towards activities that help to create a sustainable environment. Companies must also concentrate on their CSR activities and regularly review them so that their actions result in the improvement of the natural environment, as well as society and the economy, thereby fulfilling their responsibilities to the 3Ps of the Triple Bottom Line: people, planet, profit. Companies are revamping their business processes and adopting Green IT in their operations to continue achieving business sustainability. Currently, many companies are making huge investments in Green Technology and, in particular, Blockchain Technology, which is highly secure, reliable and robust. It can be implemented in different industries and can help businesses to achieve sustainability. Australia's awareness of Blockchain Technology as a Green IT and the business advantages and challenges of Green Blockchain Technology were found by means of an online survey questionnaire. The questionnaire items were created, and then the questionnaire was by the Qualtrics survey software and later evaluated and analysed using the IBM SPSS Statistics 25 software.

The study findings (see Fig. 12) answered the research questions, namely. What are the means by which individuals and businesses can be made aware of green blockchain technologies? What advantages can green blockchain technology offer to businesses, and what are its challenges? The study generated three factors for

Table 4 New Green Blockchain Technology awareness factors

Factor	Factor Loading	New Factor
Reduce air pollution	.767	**Ecological Concerns**
Reduce carbon footprint	.722	
Reduce consumption and waste of resources	.712	
Reduce climate global warming	.700	
Use recyclable materials	.673	
Reduce diseases and even death of humans	.658	
Have less packaging	.748	**Environmental materials**
Use renewable materials	.670	
Have clean emissions	.658	
Use recycled materials	.644	
Use less raw materials	.617	
Use less energy	.615	
Shifting the mode of consumption from personal ownership of products to provision of services	.805	**Ethical values**
Have portability efficiency	.794	
Have good ethical principles	.752	
Have successful production cycles	.693	

awareness: Ecological Concerns; Environmental materials and Ethical values. Three new factors were generated for advantages, namely: 3Rs; TBL; new potentialities.

Finally, the challenges generated two new factors: increasing number of scandals and increased governance. The study answered the research questions and indicated that these new factors should be considered vey carefully by businesses and decision makers before implementing green blockchain in order to minimize the challenges

Table 5 Total variance for factor related to users' perceptions of the advantages of green blockchain technology

Total variance explained						
Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	15.731	65.545	65.545	6.625	27.605	27.605
2	1.190	4.959	70.504	5.943	24.762	52.367
3	1.045	4.355	74.860	5.398	22.493	74.860

Extraction method: Principal component analysis

and to increase the advantages. In regard to awareness, using green blockchain technology will help to safeguard the environment, and businesses and can help make businesses unique and sustainable now and in the future.

There are a few limitations to this research, and they are as follows. First, there were only 101 survey respondents and they were all located in Australia. This may influence the research findings because more diverse responses would have brought more valuable insights. Second, when analysing the survey responses, it was observed that manufacturing and energy, recycling, efficiency and environmental factors did not generate any new factors individually, which means that further critical research on each factor is required. The third limitation is the time constraint. The research had to be completed within four months, that is, one university semester, so there may be a possibility that other issues relevant to the research may have been overlooked. The research was also limited by the lack of scholarly articles discussing whether Blockchain Technology can be considered as a Green Technology, so adequate information on specific issues may be lacking.

This research has targeted an Australian audience to determine people's attitudes toward and knowledge of Blockchain Technology as green Technology, in addition to the advantages and challenges that can be anticipated by businesses considering the adoption of the Green Blockchain Technology. It would be interesting to target audiences from across the globe as this would bring richness and depth to the knowledge of Blockchain Technology as a Green Technology. Moreover, Blockchain Technology must be further explored in the areas of manufacturing, energy, recycling, efficiency and the environment because, when analysing the survey data, these specific factors generated only one factor which means further research is required in these specific areas in order to fully understand how to make Blockchain technology entirely sustainable.

During the writing of this research, it was observed that Blockchain Technology offers many advantages that can help businesses to achieve sustainability. However, there are also several challenges and risks that prevent Blockchain Technology from becoming entirely Green Technology; hence, these concerns need more research. Moreover, it was also observed that there were very few studies in the literature that addressed Blockchain Technology, Green IT, and sustainability, thereby revealing

Table 6 Rotated factor matrix for advantages of green blockchain technology

Rotated Component Matrix[a]			
	Component		
	1	2	3
Reduce emissions	.814	.314	.235
Reduce carbon footprint	.792	.414	.113
Reduce Raw Materials usage	.674	.408	.311
Improve corporate social responsibility	.638	.426	.298
Enhance reputation	.636	.442	.385
Reduce energy and water usage	.630	.211	.492
Reduce pollution	.612	.250	.500
Increase cost-effectiveness	.604		.591
Increase green strategy	.552	.426	.477
Meet stakeholder expectations	.542	.451	.425
Differentiate businesses	.533	.530	.309
Improve human rights	.326	.826	.250
Improve social responsibility investing	.369	.811	.252
Attract quality employees	.336	.638	.496
Satisfy customer needs	.538	.638	.303
Reduce health hazards	.620	.621	.223
Create new jobs	.187	.600	.591
Increase triple bottom line – People, Planet and Profit	.398	.590	.537

(continued)

Table 6 (continued)

Improve community investments	.492	.555	.406
Attract new opportunities	.193	.286	.859
Reduce risk management	.205	.542	.661
Reduce paper usage	.512	.191	.645
Increase productivity	.382	.381	.641
Increase efficiency	.319	.488	.578
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization			
a. Rotation converged in 24 iterations			

the need to expand the collective knowledge regarding these three concepts. Additionally, this research targets academia and organisations, so it would be exciting to see studies on specific organisations that have or are implementing Blockchain Technology in different business areas. This could uncover more unseen potentials of Blockchain Technology, as well as its business advantages and challenges. There is little doubt that with more comprehensive research and practical experiments, issues of concern can be resolved, and Blockchain Technology can be labelled as a Green and Sustainable Technology.

6 Conclusion

This study examined the awareness, advantages, and challenges of Green Blockchain technology in Australia. Survey questionnaires were completed by 101 participant Australians. The analysis of the survey data generated various factors for business advantages and challenges. The most important advantages that businesses can acquire with Blockchain Technology include: improved TBL, a reduction in resource consumption, and better green practices. There were a few business challenges with Blockchain Technology such as strict governance and environmental compliances. In this era of environmental awareness and concern, Green IT and sustainability are essential concepts that must be considered in our every action. Organisations must adopt green technologies to enable them to perform business operations in a sustainable way, thereby causing less harm to the environment. With the advanced technologies available today, technology can enable organisations to become greener and more sustainable. Blockchain technology is considered to be an

Table 7 New advantages for green blockchain technology

Factor	Factor Loading	New Factor
Reduce emissions	.814	**3Rs**
Reduce carbon footprint	.792	
Reduce Raw Materials usage	.674	
Improve corporate social responsibility	.638	
Enhance reputation	.636	
Reduce energy and water usage	.630	
Reduce pollution	.612	
Increase cost-effectiveness	.604	
Improve human rights	.826	**TBL**
Improve social responsibility investing	.811	
Attract quality employees	.638	
Satisfy customer needs	.638	
Reduce health hazards	.621	
Create new jobs	.600	
Attract new opportunities	.859	**New potentials**
Reduce risk management	.661	
Reduce paper usage	.645	
Increase productivity	.641	

Table 8 Total variance for user's challenges towards the green blockchain technology factor

Total variance explained						
Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	9.073	69.793	69.793	5.699	43.838	43.838
2	.882	6.784	76.577	4.256	32.739	76.577

Extraction method: Principal component analysis

Table 9 Rotated factor matrix for challenges factors for green blockchain technology

Rotated Component Matrix[a]		
	Component	
	1	2
Increase scandals by perceived environmental irresponsibility	.851	.304
Increase marketing failure by perceived environmental irresponsibility	.815	.332
Increase fraud (including environmental actions and environmental compliance failures)	.794	.361
Increase governance failure (including environmental actions and environmental compliance failures)	.781	.459
Increase security and systems failures caused by environmental problems	.769	.403
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	.743	.451
Increase transaction failure due to environmental liabilities	.741	.486
Increase supply chain crises due to suppliers' environmental problems	.706	.453
Increase number of new regulations including environmental	.354	.828
Inflate costs	.373	.814
Increase insurance crises due to environmental disasters	.371	.801
Increase competition for and cost of raw materials	.370	.703
Increase interest rates	.583	.648
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization		
a. Rotation converged in 3 iterations		

Table 10 New challenge factors for green blockchain technology

Factor	Factor Loading	New Factor
Increase scandals by perceived environmental irresponsibility	.851	**Rising scandals**
Increase marketing failure by perceived environmental irresponsibility	.815	
Increase fraud (including environmental actions and environmental compliance failures)	.794	
Increase governance failure (including environmental actions and environmental compliance failures)	.781	
Increase security and systems failures caused by environmental problems	.769	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	.743	
Increase transaction failure due to environmental liabilities	.741	
Increase supply chain crises due to suppliers' environmental problems	.706	
Increase number of new regulations including environmental	.828	**Increase governance**
Inflate costs	.814	
Increase insurance crises due to environmental disasters	.801	
Increase competition for and cost of raw materials	.703	
Increase interest rates	.648	

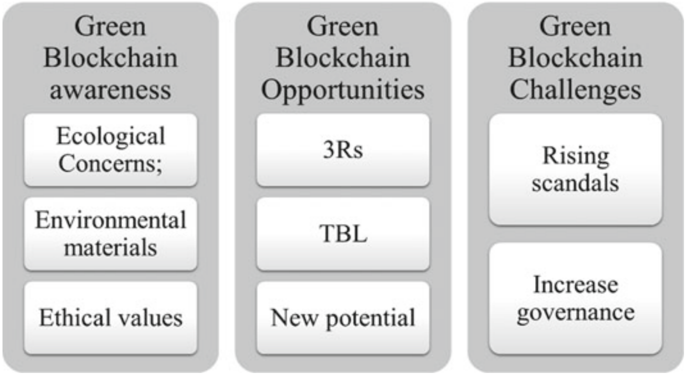

Fig. 12 New factors for the green blockchain in Australia

enabler which can help businesses to achieve sustainability. Blockchain technology is still emerging although it has already been implemented in several business domains such as supply chains, the financial sector, and energy, but has the potential to be used in many other business domains. Blockchain technology has a few challenges which are barriers preventing it from being considered as an entirely Green Technology. If the challenges are researched and addressed properly, then Blockchain Technology can be implemented in any business domain, and sustainability can then be achieved completely. In the future, further research will be carried out to examine Green Blockchain awareness, opportunities, and challenges in other countries to compare and contrast the current findings with the new data.

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Green Information Awareness, Opportunities, Challenges, Strategies

An Exploration of Attitudes of IT-Personnel in GCC Countries Regarding the Adoption of Green IT Model

Abdulaziz Albahlal

Abstract This chapter responds to the need to explore the implementation of Green IT in Gulf Cooperation Council (GCC) organisations to better understand their current Green IT initiatives and pave the way for recommendations to optimise their business IT potential for environmental sustainability. This chapter presents the data collection method (quantitative) that will refine and confirm data showing the current attitudes of IT personnel in GCC countries. Three themes were addressed by IT personnel: Information Technology, Social and Cultural and Green Management. The findings of these themes led to the development of ten factors: sustainable data centre, employees' skills development, automated sustainability, cloud computing, embedding sustainability, sustainability awareness, government responsibility, sustainability implementation, recycling management, and Green IT usage.

Keywords Green IT · GCC · Sustainability · IT personnel · GCC visions

1 Introduction

For a long time, Information Technology has transcended the realm of being a regular organisational activator to becoming an integral business strategy tool (Mingers et al. 2013). With IT emerging as a possible lifeline, it has become necessary for businesses to make appropriate IT-related decisions for the purpose of business success (Popovič et al. 2012; Işık et al. 2013). However, organisational IT mishaps have become a norm and a cause for concern (Bart and Turel 2010). Various surveys have shown that IT investment failures have been recorded at between 20 and 70% (ITGI 2008, 22). This is not acceptable for businesses, especially nowadays when many companies have established all their processes using IT (Goosen and Rudman 2013). Hence, senior executives and management boards cannot underestimate the impact of decisions

A. Albahlal (✉)
School of Management (Information Systems), Curtin University, Perth, Australia
e-mail: dr.zezo@gmail.com

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concerning IT (Henney and Donald 2006). This awareness has caused many organisations to place more emphasis on IT governance as a step to increasing business IT values (De Haes and Van Grembergen 2009). Another successful area of business IT is Green IT. Since businesses are now expected to play a significant role in contributing to a sustainable environment, the importance of IT in this regard cannot be overemphasised. Businesses should start greening their IT as well as exploring its potential for supporting behaviours that are environmentally friendly (Steg et al. 2014). Sustainability commitments can be honoured only through good governance (Aras and Crowther 2008). The inclusion of Green IT in the proposed IT governance model will assist in guiding businesses in their IT-related, decision-making processes.

This guide is particularly necessary for businesses in the GCC region. With sustainability and IT increasing rapidly in terms of strategic relevance, it is difficult for GCC organisations to move forward without IT to ensure increased productivity and meet environmental responsibilities. Hence, this research aims to determine the attitudes of current IT Personnel in GCC countries regarding the adoption of a Green IT model, so that large and dominant companies in the GCC can make better-informed IT decisions.

2 Background

Due to technological advances and financial consciousness, periodic IT reactive tasks have been superseded by more creative and pro-active roles within commercial organisations (Atkinson and McKay 2011; Hsu et al. 2018). As a result of advancements in technology and corporate consciousness, the periodic reactive work of IT within corporate organisations has been substituted by a more strategic and proactive position (Atkinson and McKay 2011; Brockhaus et al. 2017; Cui 2017). IT is now seen as a clear strategic activator to achieve organisational goals (Henfridsson and Lind 2014; Whittington 2014).

Investing in information technology has had more influence on a company's revenues than similar expenditure on advertising or research and development. However, the impacts of IT investments have been considerably more variable than investments in marketing and research and development (Smith et al. 2012). IT investments may give organisations more opportunity for creativity and innovation because IT includes different techniques to accomplish tasks. Most organisations may already understand how to handle effectively their areas of advertising and research and development, but few have developed IT strategies (Melville 2010; Smith et al. 2012; Mingers et al. 2013).

With a continuous rise in IT investment, managers are constantly seeking IT value by matching IT with investment and vice versa (Buchwald et al. 2014). This requires clear IT accountability policies along with the implementation of structures that can track the fine-tuning of IT and enterprises to a comparable frequency (Alvarez 2008;

Bokolo et al. 2018), which form the foundation for corporate IT management (Bokolo et al. 2018).

Currently, the world is facing a host of environmental issues. Temperatures are steadily increasing together with a constant rise in sea levels and a greater number of natural disasters (Gronlund et al. 2018). The changes in the natural environment has given countries in the world serious cause for concern (Bunker et al. 2016). As a result of the Kyoto Protocol that was signed in 2005 by 128 countries (Chuang and Huang 2015) and the more recent Climate Conference that was held in Paris in 2015 (COP 21) that united more than 190 countries (UNEP 2016), most nations are now doing something positive to address climate change issues globally. Governments, as well as non-profit environmental organisations, are very much aware that fighting a long-lasting and effective environmental campaign against climate change issues without the cooperation of businesses is almost impossible (UNEP 2016). Organizations are expected to create a balance between financial profitability and the environmental and social implications of their activities (Henney and Donald 2006; Dubey and Hefley 2011). Hence, Green IT entrenched in the governance of an organisation remains a key factor for ecological IT usage as well as IT implementation for all business practices that are environmentally sustainable (Thomson et al. 2015).

While the literature reports on countless IT governance studies (ITGI 2003; Raghupathi 2007; Aras and Crowther 2008; Hardin-ramanan 2016) with Green IT being assessed by different researchers (Erek et al. 2009; Wabwoba et al. 2013; Yunus et al. 2013; Liu 2014), very little has been done to ensure that both are merged in the developing countries that depend greatly on IT on the one hand and are extremely vulnerable to climate change threats on the other. Being developing nations, GCC countries have been chosen for this research. The GCC visions have prompted their governments to focus more of their attention on better governance, excellence, and IT sustainability (Shayah and Sun 2019).

However, there still seem to be significant gaps in the research on Green IT and sustainability within the GCC. The focus of this chapter is on merging the factors driving good IT in order to formulate a model for sustainability and Green IT for IT-personnel.

2.1 What Is Green Information Technology (Green IT)?

El Idrissi and Corbett (2016, p. 597) state that the development of Green IT can be observed by the increasing number of studies that it has attracted over the previous two decades, on both the effect of IT on economic problems and its position among alternatives to economic sustainability. Since every research has its own Green IT direction, and because the ideas of Green IT have broadened, numerous Green IT definitions have appeared. For instance, Murugesan (2008, p. 25) define Green IT as design, production, use and disposal of computers, servers and related subsystems such as displays, printers, storage devices and networking and communication systems in an efficient and effective manner with minimal or no environmental effect. Also, Bose and Luo (2012, p. 65) define Green IT as the energy efficient and cost-effective management of IT resources. It has also been defined as the process of effectively and efficiently designing, manufacturing and using computers, servers and various other devices to minimize environmental damage (Chou and Chou 2012, p. 447).

Most Green IT definitions take environmental sustainability over the IT cycle into consideration, as shown in earlier definitions. Some writers are also distinguishing between Green IT and sustainable IT, known as Green Information Systems (IS). For instance, Dedrick (2010) considers Green IT as a means of reducing IT carbon pollution and Green IS as the use of IS for economic solutions. Similarly, Green IT is defined by Molla and Abareshi (2012) as greening for the manufacturing, use and disposal of IT devices, while Green IS refers to the implementation of IT for green business processes. However, there is still a powerful connection between Green IT and Green IS since both contribute to the position of IT for sustainable environmental businesses. Accordingly, this study combines both Green IT and Green IS practices under the term “Green IT”.

2.2 Why Gulf Cooperation Council (GCC)?

The economies of the Gulf Co-operation Cooperation Council (GCC) are highly sensitive to the adversity of climate change, marked by a fragile desert environment and dependence on oil export revenues as its prime source of income. This necessitates the development of non-oil industries, since oil export revenues are threatened by the steps taken by other countries to reduce factors that contribute to climate change. Furthermore, dependence on oil is an inevitable threat to the region’s economic stability, making the economy susceptible to oil price fluctuations. However, environmental sustainability is likely to be a major challenge as the GCC are well prepared to decarbonize carbon capture and sequestrating oil and gas production, to reduce final consumption through improved efficiency, and to develop sustainable alternatives to energy sources, either renewables or nuclear (Giacomo and Ferroukhi 2014).

The urgency of having an appropriate and incremental response to the pressing challenge posed by climate change was discussed at the 21st Conference of the Parties (COP 21) held in Paris in December 2015 (Viñuales et al. 2017). The United Nations Framework Convention Climate Change (UNFCCC) reached a historic agreement to restrict global rises to less than 2C above pre-industrial rates on average global temperatures, and to pursue efforts to limit the temperature increase to only 1.5 °C above pre-industrial levels, believing that this would significantly reduce climate change threats and damages (Rogelj et al. 2015). The Paris Agreement, ratified in November 2016, compelled all parties to do their utmost to improve the international response to climate change by nationally determined contributions (NDCs).

Now that the agreement has come into force, the main task for governments would be to turn the mitigation and adaptation goals into actual practice. The extent to which the various nations are exposed to climate change impacts may vary depending on the different national situations. Hence, it is important to address the climate change situation in the GCC countries; this will be highly challenging, since these countries are affected not only by the adverse physical impacts of climate change, but also by the impacts of measures to reduce climate change and, especially, restrictions on fossil fuels (Giacomo and Ferroukhi 2014).

The GCC countries also rely heavily on oil and gas export revenues, accounting for almost 30% of the estimated world crude oil resources and around one-fifth of the world's natural gas reserves (Callen et al. 2014). In order to recognize their susceptibility to fluctuations in oil prices and their knowledge of the finite nature of oil and gas supplies, GCC countries have prioritized economic diversification or a reduction of their dependence on export revenues for fossil fuel, as well as the strengthening of their long-term policies regarding the economic contribution of non-oil sectors (Sultan 2012; Hvidt 2013; Callen et al. 2014).

Therefore, in order to reduce the risk of having competing approaches and additional regulatory responsibilities and inefficient budget allocations in GCC countries, it is essential to incorporate adaptation and mitigation initiatives into national long-term development strategy (Mezher and Park 2012; Callen et al. 2014). This means that the reactions of the GCC countries to climate change impacts should be integrated into current policy and decision-making processes, not implemented as a new policy. Integrating climate action into domestic economic policies will help maintain the policy at all stages. It needs cooperation among different players—federal, sub-national, local, government, private and civil societies—in order to enforce the action on climate change.

2.3 Green IT Tools for the IT Department

There are various Green IT tools available to all company departments that can help to minimize environmental harm. However, this study will concentrate on tools that are particularly helpful to IT departments, such as cloud and computer virtualization. Virtualization involving building a virtual computer rather than having a real physical machine; a virtual computer is normally used via the computer network. Cloud computing uses separate Internet-based software, which offers many advantages, including energy reduction, to run the software on the computer. There are also tools that can be used in all departments along with IT such as energy consumption reduction tools and the reduction of printing on paper. Training end users in the use of Green IT will also be an effective way to change people's thinking in regard to Green IT. End users will be given suggestions on how power and energy can be reduced by switching the computers off during non-work periods, and decreasing the quantity of paper by using electronic storage.

Gartner's results show that the average IT department consumes 62% of a company's total energy supply (Gartner 2008). The ICT community accounts for 2% of all carbon emissions globally (Gartner 2008). Concentration on IT departments will therefore provide possibilities to decrease power and save money. Power management software is used to manage electrical installations as complex as office complexes or housing structures or as simple as a single computer, saving millions of dollars (Ruth 2009). In addition, Dell has more than saved one million Dollars in power cost every year by reducing 26% of the electricity requirements of its information centre using renewable power (Cogan 2008).

In terms of manufacturers and various industry sectors globally, developing nations lead the IT revolution. Thus, sustainable practices are essential in order to decrease the environmental impact, boost profits and create the distinctive character of organizations. Recently, IT has become a main variable in organizations having to satisfy their company requirements while using natural resources, such as energy consumption, and ensuring company viability. Implementing Green IT will thus assist these organizations decrease their economic carbon footprint.

2.4 Implementation of Green IT Models in the IT Department

Changing the working environment requires a consistent strategy to prevent mistakes. In the IT department, the implementation of the Green IT model is the task that needs to be addressed properly. One of the primary objectives is to decrease energy usage, that most of the Green IT technologies aim to achieve. GREENSOFT, for example, is a tool that assists developers, managers and customers to develop and use sustainable software (Naumann et al. 2011). One of GREENSOFT's goals is to make sure the software code is set in a manner that decreases computer power consumption. Uddin and Rahman (2012) have also implemented a Green IT metrics system that reduces the power consumed by data centres by monitoring energy usage and utilizes green energy for production.

Green IT implementation could therefore be split into two categories: a technical part that relies mainly on energy usage reduction; and a theoretical part that shows consumers how to decrease harm to the environment. In addition, Power Use Efficiency is a metric that calculates the energy efficiency of an entire data centre and separates the energy produced by the quantity of energy entered in the information centre by the IT facilities. The number has to be less than one; therefore, the nearer the amount to one, the greater the energy efficiency. This tool is a Green Grid practice and is commonly used to evaluate the energy efficiency of a data centre (Van Heddeghem et al. 2012).

3 Green IT Factors for IT-Personnel

GCC is currently witnessing a quantum leap in the digital transformation of government services. These services aim to facilitate access to e-government and increase gross domestic product and the number of jobs in the long term. The public entities are developing all their services and systems to keep connected with the national digital transformation through their GCC's vision requirements. The vision includes a strategic objective for the development of the digital economy.

In partnership with the private sector, public authorities are developing an advanced digital economy that works primarily through digital technologies, supported by innovation and contributing significantly to the development of the GCC economy. This objective covers aspects of the development of digital technologies in the industrial and service sectors and their impact on the social sector. The objective also focuses on innovation in digital technologies and the contribution of the digital economy to GDP and employment.

The public sector has adopted a number of programs and initiatives that contribute to the development of the country and the digital economy, including the ministries responsible for Information Technology. The most prominent programs and initiatives include the following.

Digital Transformation Unit: The goal is to build a digital society, digital businesses and digital homes. This requires establishing digital platforms to enhance communication and efficient community involvement, so that the GCC's people, expatriates, tourists and investors can enhance their experiences. A digital economy for business development and competitiveness improvement has a positive impact on the financial position, knowledge generation and improved services of a country. Digital homes can promote innovation by supporting local and international technology and innovative investments and alliances.

Government Transaction Program: aims to improve public sector productivity and effectiveness, provide better facilities for people and entrepreneurship, and facilitate investment returns and deliver highly accurate data on time. Therefore, the information technology theme will consider all previous elements by adopting the technological elements as shown in the next section.

3.1 Smart Tech

Smart technology includes any technologies that involve computing by end-users, such as smartphones, tablet, and wearable devices. The adoption of devices has increased significantly with the technology revolution just in the last ten years, and many organisations already have high investments in these technologies. The GCC is no exception, and there are many investments by co-government organisations using phone applications to serve end-users. Therefore, this factor aims to investigate all smart technologies used by the end-users in GCC countries and ensure the best way that they can be used based on sustainability concepts.

3.2 Architecture

Green computing is becoming increasingly common and its architecture is one of the main features of green computers. Basically, architecture has five different areas: physical, operating platform, sustainable intelligence, application development and the cloud. In GCC, these elements have been partly considered and considered in most of the GCC visions. This research will investigate the current data-centre architect to determine best practice in order to shift to being greener.

3.3 Hardware

In green computing, there are many goals to achieve, one of which is to reduce the amount of hardware that runs on one platform. Moreover, employees are encouraged to reduce the amount of printed paper and use the technologies instead. Also, another way of reducing the hardware is to use virtual machines under one organisation instead of having a computer running for each client. Furthermore, almost all companies in the GCC use computer technology, although there seems to be no clear plan in terms of the use and disposal of hardware. This factor aims to investigate the current hardware used in organisations and their plans for reducing and recycling.

3.4 Software

Green software aims to reduce the environmental impact by designing, developing and using software efficiently. Therefore, software is always a critical component of the green platform, although many developers have no clear standard for this term. For instance, there are many ways to reduce power using efficient programming such as using recursion instead of a loop. In GCC, green software needs to be considered and is a part of this research as the literature shows a minimal consideration of this area. This factor aims to investigate whether software has been developed efficiently and to discover the current software being used by companies.

3.5 Training

Most organisations have a training program that aims to upgrade the employees' skills as well as increase their awareness of changes and new strategies. Green IT and sustainability are new areas that need to be considered and included in companies' plans. All GCC visions have a distinct plan for sustainable goals that need to be aligned with companies' objectives. Therefore, training is one of the means by which employees can become aware of going green. The training concerns will investigate what the current training plans are of GCC organizations and how they could include Green IT and sustainability in those plans.

3.6 Support

The support factor relates to the way that companies train their support IT team to meet the organizations' requirements. Sustainability knowledge needs to be included in the training if the IT team is going to train other employees in green practices. In the GCC, IT teams need to be considered and given the opportunity to train other employees about sustainability. For instance, they could give the employees a session on how to print any paper as a PDF document instead of using physical paper, and also how to switch the computer to doze mode when it is not being used.

3.7 Practice

Responsible computer use can help to reduce the environmental damage. Therefore, several tools can be applied to reduce the power consumption and increase production efficiency. Practical applications involve monitoring and metrics as shown below.

3.7.1 Monitor

The monitoring of devices can help to determine their usage in data centres and can obtain real-time data about their power consumption. Monitoring can help data centres to reduce power consumption and encourage them to install new and more efficient devices.

3.7.2 Metrics

Metrics is a small software that is programmed to reduce the power consumption and increase the efficiency. These metrics need to be installed by users or administrators, or by a third party, or programmed locally.

4 Research Question and Method

This research seeks to discover factors that enable IT personnel in GCC countries to be more sustainable and environment-friendly, particularly those in IT departments. Also, it investigates what is already known about Green IT and sustainability in

GCC countries and proposes concrete improvements to current systems. Therefore, the main aim of this research is to determine the factors needed that suit IT personnel in GCC countries in order to shift to green by adopting a Green IT model. The research question is: "What are the factors which encourage IT personnel in the GCC countries to adopt a Green IT model?".

Researchers should consider all Green IT factors such as paperless systems, e-archiving, virtualization, energy control systems, cooler systems and recycling in order to create a new Green strategy as, "currently IT infrastructures contribute about 2% of total CO2 footprints" (Uddin and Rahman 2012, p. 2064). The principal practical importance of this investigation is to examine the current GCC data centres and to use Green IT factors to determine whether the data centres comply with the Green IT model. For example, the workplace observations technique is used for measuring energy consumption, floor layout, server settings, consolidation of servers, cabling factors and optimisation of power supply (Toby et al. 2008).

In order to gather survey data, the researcher needs to identify the target population then select a sample and, finally, administer the survey questionnaire. Saunders et al. (2015) advise researchers to pinpoint a target population which is very accurate, and that may mean using multiple sources of information. In this case, the target population of personnel in IT positions in the GCC companies was determined using the (Bartlett et al. 2001) sample size calculator.

Subsequently, this target population was refined by the researcher making calls to as many organisations as possible to identify mergers and closures and to discover whether the organisations had a reliable IT infrastructure headed by an executive team. Websites and social media were also used to obtain additional relevant information.

After identifying the target sample populations, questionnaires were sent to relevant organisations that were initially identified as the target population to enhance the chances of obtaining reliable findings from a good response rate. Company executives and high-ranking managers targeted here are known to keep tight schedules while at the same time facing an avalanche of opinion requests from various sources. This results in profoundly low survey response rates (Cycyota and Harrison 2002). Also, Cycyota and Harrison (2006) recommended that a 32% survey response rate by high ranking company managers is acceptable while Baruch and Holtom (2008) claim that between 35 and 40% is sufficient.

Once the population identification has been made and the questionnaire completed, the survey process is ready to be carried out. This research targeted all company managers (business and IT included), non-IT employees and IT employees as research respondents. This decision was taken for four reasons.

Cycyota and Harrison (2006) recommended using current CEO networks to collect contacts so as to improve the survey response rate. A cover letter inviting and requesting participation in the research (De Vaus 2013) attached to a research questionnaire was sent to every potential participant. The cover letter outlined the objectives of the research and briefly highlighted the topic in order to improve the response rate (Dillman and Carley-Baxter 2000; Cycyota and Harrison 2006; Rogelberg and Stanton 2007).

The cover letter and research questionnaire were distributed to the participants through their emails and were not sent by post or hand delivery except for those who wanted hard copies. Due to concern for Green IT and time constraints, the email transfer of both the questionnaire and cover letter were the preferred method of distribution.

Baruch and Holtom (2008, p. 1151) found that surveys delivered via emails returned a 54.7% response rate compared to a 44.7% return of mailed surveys. Ensuring that every email is tailored to the participant and delivered directly to them improves survey response tremendously (Dillman 2011).

Adobe software was used to design and send an interactive questionnaire, while Qualtrics Survey Software was used to prepare questionnaire for online distribution and use. This format provided an added advantage in that participants were able to respond to the questionnaire quickly by completing it online. It also facilitated easy and almost real-time tracking of the participation by the researcher as the questionnaires were returned upon completion, making it easy to conduct personal follow-ups. Both formats of the questionnaire were interactive, thereby improving the survey response rate (De Vaus 2013).

In order to improve the rate of response, Saunders, Lewis, and Thornhill (2015) recommend carrying out follow-ups one week after the initial distribution of questionnaires. Follow-ups are an important means of keeping track of all potential participants who may have misplaced or did not receive questionnaires, could have been busy or just did not remember the survey (Rogelberg and Stanton 2007). Carrying out follow-ups indicates the seriousness of the survey as well as the participation of respondents (Cycyota and Harrison 2002).

To further encourage participants to respond, follow-ups were done through phone calls. In instances where participants were unreachable by phone, the researcher sent emails or messages as reminders.

4.1 Analysing Survey Data

Raw data obtained from research respondents were converted into information for analysis. For the purpose of analysis, numerical data were entered into a statistical data analysis application which also allows any errors to be identified (Creswell and Plano Clark 2017). A codebook or coding scheme (Saunders et al. 2015) with codes given to possible responses for every questionnaire item is first created. This helps to code appropriate questionnaire data numerically and to enter data in the SPSS version 23 application and create a file. Upon receiving completed questionnaires, collected data was recorded and carefully coded to reduce typographical errors.

To avoid inaccuracies in statistical conclusions (Segars 1997), confirmation as to whether survey matters depicted their corresponding mechanisms consistently (reliability) and accurately (validity) was done. Exploratory Factor Analysis (EFA) was conducted to determine reliability and validity. This method produced similar results, confirming the theoretical expected behaviour stated by sustainability mechanisms and Green IT that the targeted population was reliably and accurately depicted via the survey items. EFA was applied to show factors or latent variables in items related to the sustainability model and Green IT mechanism.

Based on the recommendations of Straub, Boudreau, and Gefen (2004) for information technology research, the explored forms of validity were: (a) construct validity, (b) factorial validity and (c) unidimensional validity.

Construct Validity: determines the extent to which the items in the survey questionnaire actually record the basic factor principle or the underlying latent variable (Segars and Grover 1993). This is established when factor items display both discriminant and convergent validity. While convergent validity determines the level to which items in factors are related, discriminant validity determines whether items across various factors are unrelated (Gefen et al. 2003).

Factorial Validity: ratifies whether all factors represent a single fundamental construct (Straub et al. 2004).

Unidimensional validity: checks whether every item reflects only a single latent variable (Gefen et al. 2003).

Internal consistency was used to determine the reliability of every item for each factor. This determines the extent of the correlation between items as measured by the Cronbach's (1951) alpha index.

5 Data Analysis and Finding

Each participant was asked to state his/her job position at the beginning of the survey, then the survey tool would automatically appear for subsequent questions based on the stated position. The survey questions were derived from the interview data and the literature review. The questions asked were based on the participants' job position, as shown in Fig. 1, to ensure that all items relevant to a Green IT and sustainability model for GCC countries, were covered. At the beginning of the questionnaire, the researcher asked general questions to collect the demographic data. These questions were presented as multiple choices in single and matrix format for various answers. Also, the first part of the survey comprised a five-point Likert scale

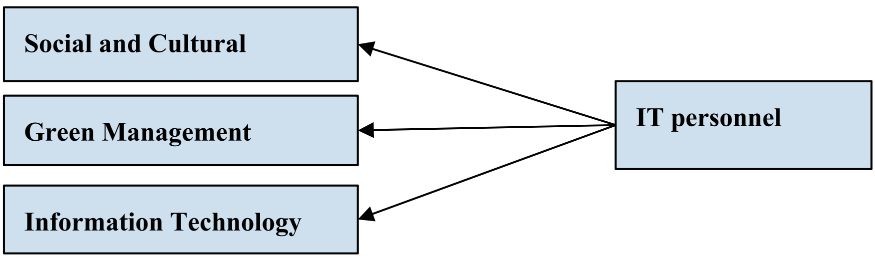

Fig. 1 The survey structure of the Green IT model for IT personnel (developed by the researcher)

anchored by ‘strongly agree’, ‘agree’, ‘neutral’, ‘disagree’, and ‘strongly disagree’. Each theme (for example, managers have three themes: Governance, Social and Cultural, and Green management) is dealt with on a single page. In addition to having the demographic page, managers saw four pages, IT-personnel four pages, and non-IT personnel had three pages. The researcher conducted multilabel testing on several people to test the timing of the answer, and the results showed that 10–12 min would be required to complete the questionnaire.

5.1 Developing the Survey Questions

Qualtrics was used for conducting the survey. It is a web-based tool used to design a survey and distribute it to the targeted audience. Moreover, Qualtrics can be used to print the survey questionnaire as a hardcopy for physical distribution. The single format section contained the demographic questions, and the matrix format was used for the structured model. The first step in developing the survey questions involved the design of the initial prototype model using the data from both the literature review and the qualitative phase. After designing the initial survey questionnaire, the researcher met with the supervisor multiple times to ensure that all areas were covered.

5.2 Data Analysis Using Exploratory Factor Analysis (EFA) Method

As shown in Fig. 2, EFA has a sequential processing that was introduced by Williams et al. (2012); the first step is establishing all the factors, then the appropriate techniques for extraction are selected; thirdly the number of factors is generated, fourthly

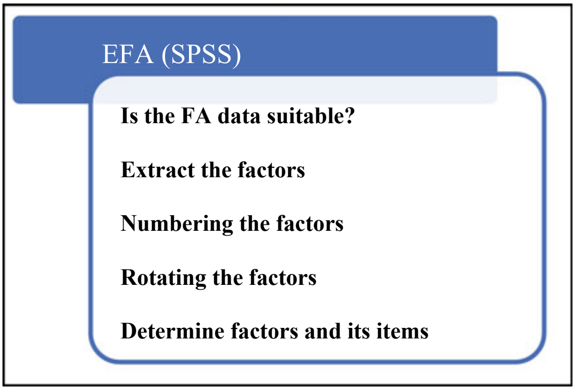

Fig. 2 Survey data analysis process

Table 1 EFA requirements summary

Step	Values
1. Determine whether the FA data is suitable	Item correlations ≥ 0.3
	Bartlett's test < 0.05
	KMO > 0.6
2. Extract the factors	PCA
3. Number the factors	Eigenvalues > 1
	Scree test
4. Rotate the factors	Varimax
5. Determine factors and their items	Cronbach $\alpha > 0.7$
	Factor loadings ≥ 0.45
	Communalities > 0.5

the right rotation method is executed; lastly, the factors and their items are identified. Therefore, for analysis of the survey data, the EFA technique is preferred as it has clear steps and is easy to follow. Each step will be described briefly in the sections below.

Table 1 shows each step and the value for each item. The column on the left shows the steps of the PCA factor extraction method. All the values are given in the column on the right.

5.3 Data Analysis

The primary analysis conducted in this chapter has three themes: Social and cultural, Information Technology, and Green Management.

5.3.1 Social and Cultural

The factorability test using EFA for the social and cultural theme resulted in the deletion of various statements due to either low commonalities or cross-loading scores. Figure 3 shows that the test introduced four factors for this section. The test measured the reliability of items, the theme scores 0.784 for all the 18 items that accepted, and the KMO and Bartlett's test scored 0.631, ($p < 0.0001$) which is acceptable result.

The scree plot for this analysis is just after the number one as shown in Fig. 4, indicating that factors after number one are accepted. Table 2 shows the results of the analysis indicating factorability using principal component analysis conducted on 18 items. The factor correlations accept all items that score above 0.45. Also, as shown in Fig. 3, the results are four factors with a variance contribution of 22.8%,

Reliability Statistics

Cronbach's Alpha	N of Items
.784	18

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.631
Bartlett's Test of Sphericity	Approx. Chi-Square	792.747
	df	153
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.118	22.876	22.876	4.118	22.876	22.876	3.294	18.301	18.301
2	2.703	15.014	37.890	2.703	15.014	37.890	2.492	13.842	32.143
3	2.017	11.207	49.097	2.017	11.207	49.097	2.368	13.157	45.300
4	1.533	8.516	57.613	1.533	8.516	57.613	2.216	12.313	57.613

Fig. 3 EFA result for social and cultural section

15%, 11.2%, and 8.5% respectively. The total variance is 57.6% which indicates acceptable results; scree plots show the entire elbow curve for the eigenvalues.

As shown in Table 3, the parallel test accepted only four factors, whose eigenvalues show that they are acceptable for further analysis.

The four factors that are shown in Table 2 named "sustainability awareness" indicate the most items related to people's awareness of sustainability. The second factor, "Embedding Sustainability," relates to the way that sustainability could be implemented within the social sector. "Sustainability influence" is the third factor, as the cross-loading items related to how sustainability influences people by using the media. Lastly, the fourth factor is "Government responsibility", as the items related to how the government will act to encourage the current society to be more sustainable.

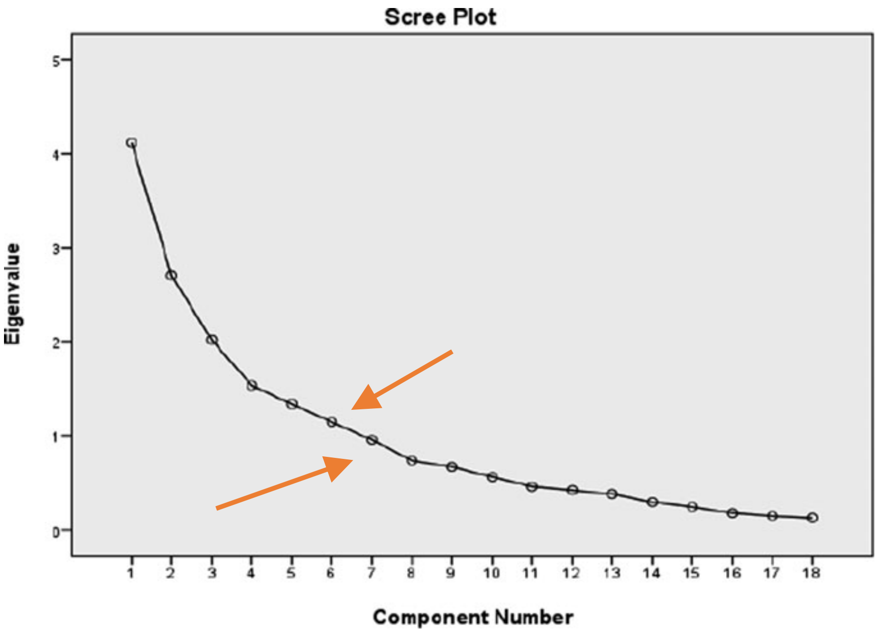

Fig. 4 Scree plot for social and cultural section

5.3.2 Green Management

In this theme, a number of items were deleted due to their weak contribution to the model. The overall Cronbach's Alpha score is 0.777, and KMO is 0.702, which is a good score for factorability, as well as giving high communalities results, as shown in Fig. 5.

The data was analysed using principal component analysis. There were eleven items reined to the factorability test results in accepting two factors. As shown in 5, the items' correlations are all above 0.45. The total variance for each factor's contribution to the total variance is 40.6% and 22% respectively, giving a total of 62.2%.

The SPSS only two factors to be chosen because at the start it gives a low number of items with low communalities. In the scree plots, the elbow point shown in Fig. 5 in the medial of number one, which means that all the factors score above one in eigenvalue. In addition, the parallel test accepts two factors as shown in Table 4, which means the results support the two factoring results.

Table 5 shows the factor loadings for the two proposed factors. The first factor is named "Recycling management", as most items relate to managing the recycling process using different methods. The second factor is named "Green IT usage" as the items relate to the way that organisations can use Green IT.

Table 2 Summary of the factor analysis results

		Factors items	Factors			
			1	2	3	4
Factors	Sustainability awareness	People are not aware about the environment	0.902			
		People are not aware about reducing paper wastage	0.823			
		People are not aware about sustainability	0.782			
		The most-used media channel is social media	0.772			
		We have to include sustainability in the school curriculum	0.597			
	Embedding sustainability	I prefer companies that claim to be environment-friendly		0.719		
		Companies that claim to be environment-friendly are attracting business		0.674		
		We have to use only recycled paper in schoolbooks		0.590		
		Organizations are responsible regarding social issues		0.585		
		We have to reduce paper usage in schools by utilizing technology		0.557		
	Sustainability influence	The most-used media channel is newspapers			0.839	
		The most-used media channel is television			0.811	
		We have to Separate bins to rubbish and recycle			0.604	
	Government responsibility	The government should force organizations to be responsible regarding social issues				0.781
		The government should raise public awareness about CSR through the schools				0.713

(continued)

Table 2 (continued)

		Factors items	Factors			
			1	2	3	4
		Organizations need to be more aware of their corporate social responsibility (CSR)				0.530
		Social media is the best way to change people's attitude toward sustainability				0.490
		Social media can increase people's acceptance of a Green IT model				0.482
		Cronbach alpha test	0.853	0.709	0.746	0.718

Table 3 Parallel test for social and cultural theme

Factor	Actual eigenvalue	Generated eigenvalue	Decision
1	4.118	1.983547	Accepted
2	2.703	1.768205	Accepted
3	2.017	1.580550	Accepted
4	1.533	1.477888	Accepted
5	1.335	1.364918	Rejected

5.3.3 Information Technology

For the information technology section which contained the greatest number of items, several factorability tests were conducted to increase the reliability and reduce the cross-loading factors. This resulted in 23 items being accepted and categorised under four factors as shown in Fig. 6. The Cronbach's Alpha reliability test for this section yielded a score of 0.808 for all the items, score of 0.613 for the KMO, and ($p <$ 0.0001) for the Bartlett's test of sphericity, which means the entire factor is eligible for EFA.

As shown in Fig. 6, the factor contribution variance for each factor score is 20.4%, 13.1%, 10.6% and 9.9% respectively from total variance; which means the total variance for the four factors represents 54.1% of the overall variance. In the scree plot shown in Fig. 6, the elbow cross is just before number 2, as the system was forced to generate four factors, and all the factors must be above one eigenvalue. For the parallel test, only four factors were accepted, which supports the results of the reliability test as shown in Table 6.

Reliability Statistics

Cronbach's Alpha	N of Items
.777	8

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.702
Bartlett's Test of Sphericity	Approx. Chi-Square	315.148
	df	28
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.250	40.626	40.626	3.250	40.626	40.626	2.727	34.090	34.090
2	1.767	22.093	62.719	1.767	22.093	62.719	2.290	28.629	62.719

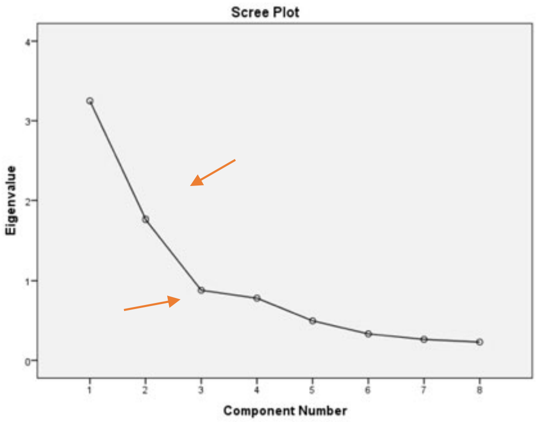

Fig. 5 EFA result for Green management for IT personnel section

Table 4 Parallel test for Green management theme

Factor	Actual eigenvalue	Generated eigenvalue	Decision
1	3.250	1.593176	Accepted
2	1.767	1.364600	Accepted
3	0.880	1.205935	Rejected

Table 5 Summary of the factor analysis results of Green management for IT personnel

		Factors items	Factors	
			1	2
Factors	Recycle management	Reusing our equipment in our work	0.853	
		Recycle (for example paper and equipment) is in our organization	0.846	
		Updating and upgrading computers is very costly	0.704	
		The government is applying the recycling program	0.678	
		Updating and upgrading computers is takes a long time	0.521	
	Green IT usage	Updating and upgrading computers is makes it hard to destroy old data		0.848
		Organizations is concerned about purchasing environment-friendly products		0.831
		Organizations believes that price is not an issue if the product has better features		0.800
		Cronbach alpha test	0.785	0.791

Table 7 shows the factor loadings for the Information Technology theme. Four loading factors for 23 items are available for this theme. The first factor is "sustainable data centre", as the factor loading focuses on the data centre items in terms of virtual machines and cloud solutions. The second factor is named "employees' skills development", as the factor loading related to sustainable development for the current employees. The third factor is named "automated sustainability", as the items relate to the computing metrics for the IT support team. The last factor is named "cloud computing", as the items relate to cloud computing in practice and business.

The last themes for IT personnel are shown in Fig. 7 which shows all the theme sections and their factors. Therefore, the tree has three themes: Information Technology, Social and Cultural and Green Management. Each one of these is connected to the factors newly generated from EFA.

6 Discussion and New Findings

IT personnel responded to three themes: Information Technology, Social and Cultural, and Green Management. Each theme also has multiple factors: sustainable data centre, employees' skills development, automated sustainability, cloud computing, embedding sustainability, sustainability awareness, government responsibility, sustainability implementation, recycle management and Green IT usage. The

Reliability Statistics

Cronbach's Alpha	N of Items
.808	23

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.613
Bartlett's Test of Sphericity	Approx. Chi-Square	1200.847
	df	253
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.694	20.407	20.407	4.694	20.407	20.407	3.903	16.969	16.969
2	3.031	13.179	33.586	3.031	13.179	33.586	3.104	13.497	30.466
3	2.445	10.629	44.215	2.445	10.629	44.215	2.788	12.122	42.588
4	2.278	9.905	54.120	2.278	9.905	54.120	2.652	11.531	54.120

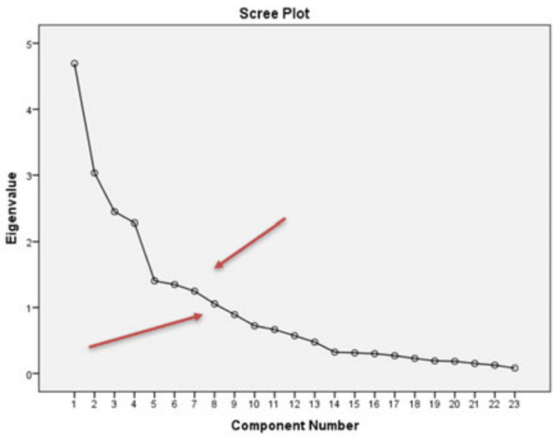

Fig. 6 EFA result for information technology of IT personnel section

Table 6 Parallel test for information technology theme

Factor	Actual eigenvalue	Generated eigenvalue	Decision
1	4.694	2.162456	Accepted
2	3.031	1.917757	Accepted
3	2.445	1.774822	Accepted
4	2.278	1.628343	Accepted
5	1.405	1.521313	Rejected

Table 7 Summary of the factor loading results for the information technology theme

		Factors items	Factors			
			1	2	3	4
Factors	Sustainable data centre	When our data centre requires more storage, I would prefer to—increase storage capacity (traditional method)	0.793			
		In our data centre—focus on quality—nothing else	0.764			
		Installing a virtual machine—is very difficult	0.665			
		Installing a virtual machine—requires experts	0.652			
		Technologies that we are using in my organization are increases the efficiency of our business operations	0.622			
		Technologies that we are using are very useful for our business	0.616			
		We are using Email as the primary method to finish our work	0.550			
		When our data centre requires more storage, I would prefer to—use cloud solutions	0.528			
	Employees skills development	When our data centre requires more storage, I would prefer to—change the recovery method		0.757		
		When our data centre requires more storage, I would prefer to—remove old data to make room for the new		0.658		
		Storing business data via reputable companies—lead to data being stolen or not saved		0.622		
		In order to develop our skills, our organization—has a library and training sessions rooms		0.584		

(continued)

Table 7 (continued)

		Factors items	Factors			
			1	2	3	4
		In order to develop our skills, our organization—provides very useful training for self-learning		0.582		
		In order to develop our skills, our organization—provide training on request		0.507		
	Automated sustainability	our support team is—they provide classes for training new systems			0.914	
		Using computer metrics for our datacentre (for example power management)—is a powerful tool			0.887	
		Using computer metrics for our datacentre (for example power management)—give us more control of our machines			0.700	
		Our support team is—they do have different people for different issues			0.616	
	Cloud computing	Using a virtual machine—is difficult compared with regular computers				0.850
		Storing business data via reputable companies—mean that only non-sensitive data could be stored				0.794
		Using a virtual machine—has saved me many times (data stored in the Datacentre)				0.679
		In our data centre—have a heat management system				0.489
		In my organization we are needs to be upgraded our technology				0.482
		Cronbach alpha test	0.817	0.742	0.813	0.744

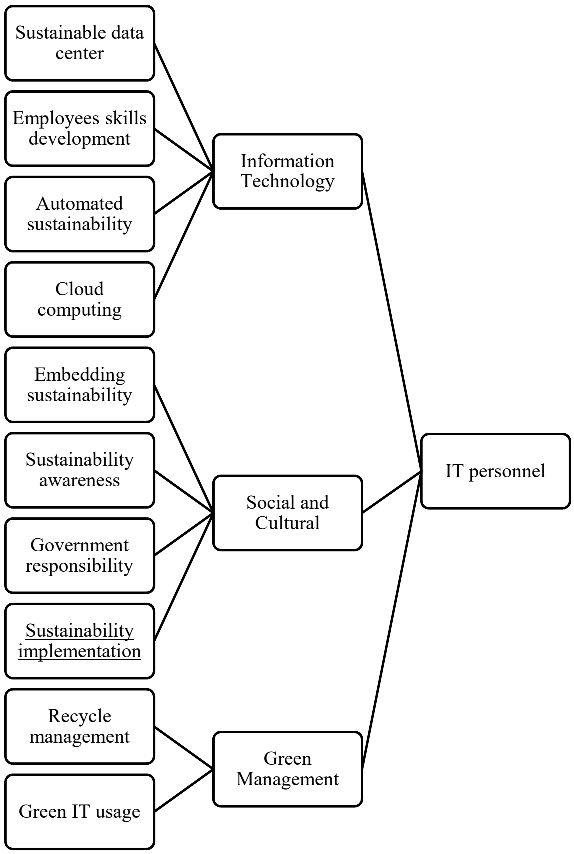

Fig. 7 Themes and factors for IT personnel section

IT personnel section contained the greatest number of survey items as the research was strongly focused on the Information Technology theme. IT personnel believe that technologies and innovation are the key to changing to Green IT and sustainability.

In an attempt to support Green IT procedures, the organisations examined have taken advantage of Green technology by using (1) energy-efficient equipment, (2) virtualisation, (3) power effectiveness promotion tools and (4) energy-efficient graphics. The implementation of Green IT technology processes is strongly supported in the literature. For example, Hedman and Henningsson (2011) found that in Danish companies, virtualisation is a successful and popular practice. Jain et al. (2011) have referred to virtualisation, based on their study, as a very prevalent Green IT technology. Green IT technology such as computer virtualisation and energy-efficient equipment are being adopted by organisations in Taiwan to encourage greater company responsibility for the environment (Chuang and Huang 2015).

Molla et al. (2011) recognised energy-efficient lighting, as a type of green IT technology, based on an assessment carried out by their Australian companies. Ardito and Morisio (2014) are aiming for energy-efficient buildings with eco-innovations such as Building Management Systems. Software for resource efficiency promotion, like collaborative software, are usually used in Chinese organisations (Shi et al. 2010), also seen as efficient IT enforcement interventions for environmental sustainability. Therefore, Information Technology is intended to help organizations to implement green IT by following the practices described below.

6.1 Sustainable Data Centre

Demand for information centre computation has recently increased, and the overall power consumption by information centres globally has also increased. Typically, data centres contain three subsystems: IT hardware offers customer services; energy infrastructure produces IT and heating facilities; and the cooling infrastructure reduces heat produced by these subsystems. This factor represents a GCC organisation's approach to modelling the energy flows of a data centre and optimising its operation using Green IT concepts. These include regular equipment upgrades as one way to make IT more ecologically safe, as well as adding environmental considerations to IT infrastructure architecture (including data centres).

6.2 Employees' Skills Development

As other aspects of commercial achievement have become less significant, what remains essential is the organisation, its staff, and how they operate. Employment safety and the dependence on employees to achieve sustainable goals require that appropriate individuals be selected in a correct way. Many GCC organisations as well as local libraries offer skills development training courses (hands-on, online). Therefore, this factor relates to the best practices that can help develop green skills for employees in GCC countries. The research found that each organisation has its own program and what it offers depends on the budget allocated by the organisation. However, most of the employees prefer hands-on training and courses.

6.3 Automated Sustainability

Environmentally friendly IT providers, as well as several other Green IT requirements for IT purchases (such as green tags and energy-efficiency labels), demonstrate that GCC organisations have been exploring the practices of ecologically responsible IT vendors. These methods are consistent with long-lasting, viable IT buying values suggested in the literature (Erek et al. 2009) to encourage consumers to consider Green IT in their purchasing strategies. Therefore, automated sustainability tools that help data centres to operate efficiently could be developed locally or implemented by third-party companies. These tools may be in the form of computer metrics or sustainability tools training from the support team to the end-user. The research found that this tool is useful for organisations in GCC countries.

6.4 Cloud Computing

Cloud computing provides online connectivity to people globally. This system results in higher installation and operating costs of cloud information centres as well as significant environmental pollution footprints. Green cloud computing alternatives need to be developed that decrease these operating and implementation expenses, thus saving energy and reducing negative economic effects. A thorough knowledge of energy usage habits in complicated cloud settings is required in an attempt to attain this goal. This factor presents a fresh model for energy use and a related cloud-based analytical instrument for organisations in GCC countries. In cloud settings, the amount of energy consumption depends on the nature of various operational tasks. Empirical analyses will be explored based on a power usage model and evaluation instrument for the comparison of power usage and cloud information with computing activities and scheme efficiency. In cloud technologies, the research findings in regard to monitoring energy consumption can be used to facilitate linear or vibrant system-level optimisation.

6.5 Answering the Research Question

The research question is: what are the factors which encourage IT personnel in the GCC countries to adopt a Green IT model?

The research indicates that the use of Green IT and sustainability facilities was accepted by IT personnel who did not believe that cultural aspects of the GCC were a serious impediment to the success of Green IT. However, the current culture and behaviour of GCC people shows that there is the need for a stronger awareness of Green IT concepts. Although some barriers were mentioned, IT employees were positive about applying the recent Green IT technology in their IT departments because of the variety of useful tools that green IT provides. This aligns with the reshaping of the GCC to achieve the goals of its vision.

6.6 Research Limitations and Future Study

Every research project has limitations, which can point to avenues of future research. Likewise, this research had limitations, some of which relate to the cultural characteristics of GCC countries.

Firstly, budget constraints proved to be a significant limitation. The GCC comprises countries that are huge as well as geographically dispersed. Therefore, the researcher could not afford the cost of accommodation and flights for the two data collection stages. This situation was made worse by the researcher residing in Australia. Nevertheless, the researcher undertook two trips to the GCC countries for the purpose of collecting data.

Additionally, the time difference between Australia and the GCC was also a hindrance, because contacting participants was more challenging. This is because GCC companies' working hours do not coincide with those of companies in Western nations, with lengthy holiday periods being an added complication. These factors affected the ease with which communication was conducted with GCC companies and with participants when attempting to make arrangements for the collection of data.

Furthermore, the required data was obtained from companies within the metropolitan region, which meant that regional and rural population samples were not included in the research. Another obstacle was the bureaucracy of GCC companies. These are distinctly hierarchical, making it very difficult to obtain permission to conduct the research. Additionally, not every organisation's departments were positive about the research, consequently rejecting requests.

Finally, from a practical point of view, numerous incomplete responses were returned. This indicated either the participants' lack of motivation to complete the voluntary survey, or their lack of familiarity with the concepts constituting the basis of this research.

7 Conclusion

This chapter explores the attitudes of current IT personnel in GCC countries regarding the adoption of a Green IT model. A survey was distributed to IT personnel in GCC countries; the survey data was analysed, leading to several conclusions.

IT personnel responded to three themes: Information Technology, Society and Culture, and Green Management. Each theme has multiple factors: sustainable data centres, development of employees' skills, automated sustainability, cloud computing, embedding sustainability, sustainability awareness, government responsibility, sustainability implementation, management of recycling and Green IT usage. The survey's IT personnel section contained the greatest number of survey items as the research was strongly focused on the Information Technology theme. IT personnel believe that technologies and innovation are the key to shifting to Green IT and sustainability. This chapter is part of a thesis titled "Green IT Model for Gulf Cooperation Council Organisations", that contains a more comprehensive investigation in this research field.

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Awareness, Opportunities and Challenges of Green IT: An Australian Perspective

Tomayess Issa, Theodora Issa, and Touma Issa

Abstract Human beings have been responsible for the majority of the damage done to the natural environment. The problems created by humans must be tackled immediately and effectively so that the next seven generations can enjoy the same lifestyle as we do. Unfortunately, there is no Plan B for our planet. Therefore, to minimize the impact from e-waste, energy usage, and other ICT practices on Mother Nature, businesses and individuals can integrate Green Information Technology (IT) in their corporate strategies and daily work. This study aims to examine the awareness, opportunities and challenges of Green IT adoption in Australia. An online survey was distributed to 157 participants in Australia. From this study, new factors are generated for awareness, challenges and opportunities; awareness factors are namely: e-waste, eco-friendly materials and design efficacy. For the opportunities, three new factors are generated namely: environmental value, productivity and new opportunities, while the challenges generated three new factors namely: the rise of scandals and failure, the upsurge of cost and rates, and the escalation in competition and environment policies; in order to mitigate these challenges designers should very carefully consider their strategies. The new factors for this study will encourage Human Computer Interaction and IT researchers to integrate Green IT concepts within their designs in order to save our planet, as our planet is currently suffering and deteriorating as a direct result of human actions and activities.

Keywords Green IT · Awareness · Opportunities and challenges · Australia

T. Issa (✉) · T. Issa
School of Management, Curtin University, Perth, WA, Australia
e-mail: Tomayess.Issa@cbs.curtin.edu.au

T. Issa
e-mail: Theodora.Issa@cbs.curtin.edu.au

T. Issa
Discipline of Engineering and Energy, College of Science, Health, Engineering and Education, Murdoch University, South St, Murdoch, WA 6150, Australia
e-mail: T.Issa@murdoch.edu.au

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1 Introduction

Currently, the technology used by businesses and individuals improves productivity and performance, and generally makes our lives easier. However, the use of this technology has harmful side effects including e-waste, pollution, carbon emissions, and the overuse of raw materials. Therefore, in order to reduce this impact Green IT should be adopted by businesses and individuals. This chapter aims to examine Green Information Technology (IT) awareness, opportunities and challenges in Australia. Green IT awareness gives the opportunity to be unique and exceptional in design, and this can lead to creativity and innovations in research. Furthermore, Green IT awareness can contribute to the improvement of the environment, to social equity and to growth and profit in the expanding global community. This awareness will lead the designers to action orientation and learning, and to a new level of concern based upon this new knowledge and commitment. Green IT opportunities and challenges are used to justify whether using Green IT in industry and by individuals is useful. This study generated three new factors for each aspect of Green IT: awareness, opportunities and challenges in an Australian context.

From the methodological, theoretical and practical perspectives, the findings from this study will make a significant contribution to the corpus of current literature on Green Technologies usage among businesses and individuals in order to become more sustainable. The most important aspect of this research is to reduce the impact of technology, including waste, energy usage, and pollution, on Mother Nature. This study was limited to Australia. Therefore, in the future researchers will need to examine other countries in order to compare and contrast the stakeholders' awareness, opinions and attitudes to the adoption of Green Technologies.

This chapter will present an Australian perspective on the awareness, opportunities and challenges of Green IT in Australia. This chapter is organized as follows

(1) Introduction
(2) What is Green Information technology?
(3) Research Methods and Question
(4) Results
(5) Discussion and New Findings
(6) Conclusion.

2 What Is Green Information Technology (IT)

Technology exists in order to make our life easier; it improves productivity, the economy, and even social interaction. Through technology users and businesses can easily collaborate, communicate, co-operate and connect. However, technology also consumes energy, increases carbon footprint and generates waste. Therefore, to minimize these impacts on Mother Nature, Green IT must be introduced and adopted.

Green IT (Green Information Technology) is the practice of environmentally sustainable computing with the aim of minimizing the energy consumption and environmental impacts of computing resources, harnessing the power of IT and IS to empower; and leveraging IT to help create awareness among stakeholders and promote a Green agenda and Green initiatives (Murugesan 2008) Several studies (Issa et al. 2017; Issa and Issa 2019; McCabe 2010; Murugesan 2010; Murugesan and Laplante 2011; Smith 2014) indicate that dealing with environmental concerns and implementing environmentally friendly programs should be the main focus for the businesses and individuals to minimize the negative impact of IT operations on Mother Nature.

Green IT aims to minimize the negative impact of IT operations on the environment by designing, manufacturing, operating and disposing of computers and computer-related products in an environmentally friendly manner.

Green IT practices include reducing the use of hazardous materials, reducing e-waste, maximizing energy efficiency during the product's lifetime and promoting the biodegradability of unused and outdated products, sharing of resources through cloud computing, reducing carbon footprints by allowing work from home through remote computer management (Babin and Nicholson 2011; Issa and Issa 2019; Prasad et al. 2010; Vereecken et al. 2010; Weybrecht 2010).

Generally speaking, Green IT adoption by businesses and individuals benefits in several aspects including social development, environmental protection and preserving resources for the next seven generations. It is essential for Green IT practices to be adopted immediately in order to minimize the harmful aspects and reap the rewards of the benefits.

The most important aspect of Green IT can be said as the 3R's—Reduce, Recycle, and Reuse (Halpin 2008; Laurent 2008; Murugesan 2008). This study aims to examine the awareness, opportunities and challenges of Green IT in Australia.

Several studies (Adomßent et al. 2014; Ali et al. 2018; Gijzen 2013; Grover et al. 2020; Hauschild et al. 2018; Hayward 2012; Issa and Isaias 2015b; Jaffe et al. 2020; Petrova et al. 2019) indicate that the factors of Green IT awareness are concerned with design, safety, manufacturing and energy use, recycling, efficacy and social responsibility (see Fig. 1).

While the factors of opportunities are mainly focused on the financial areas, including brand and reputation, human resources and shareholders, and environmental impacts (see Fig. 2).

On the other hand, the challenges are mainly concentrated on the possibility of failure and the cost of implementing and conducting Green IT practices (see Fig. 3). Based on this information, an online survey was generated and conducted in Australia.

Finally, the main Green Technologies are namely: Virtualization, Cloud Computing, Social Networking, Smart Technology, Blockchain, Drones, Robots, IoT (Internet of Things), 3D Printing, AR (Augmented Reality), VR (Virtual Reality), AI (Artificial Intelligence) and Big Data. These new technologies will assist businesses and individuals to achieve the aims of Green IT and help solve the current IT issues that are damaging our planet.

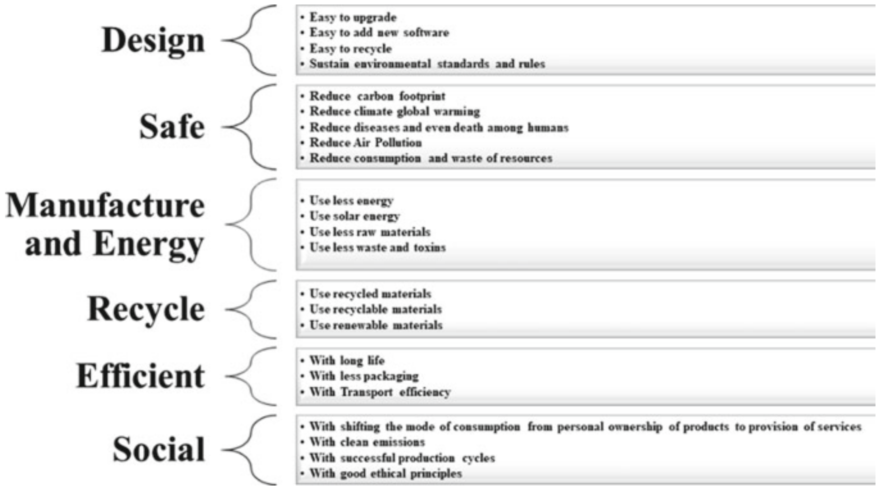

Fig. 1 Factors of Green IT awareness

Fig. 2 Factors of Green IT opportunities

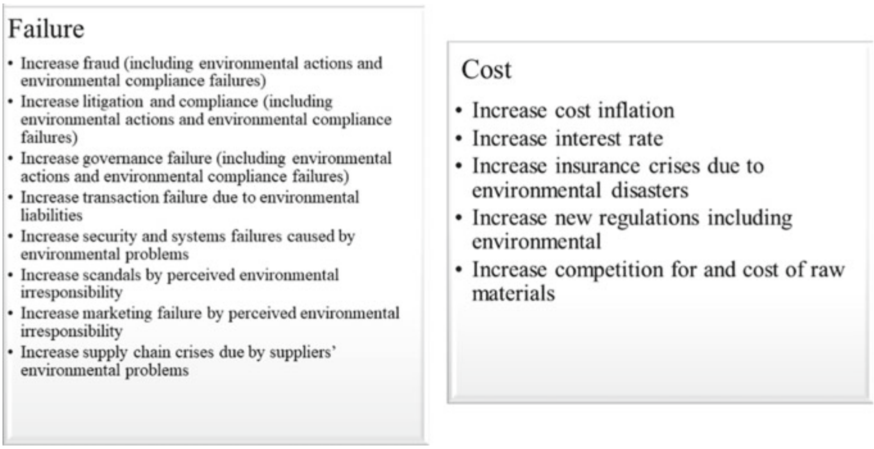

Fig. 3 Factors of Green IT challenges

3 Research Method and Questions

This study addresses a research question, namely: "What are the awareness, challenges and opportunities of Green Information Technology in Australia?". An online survey was developed based on the literature review to address the research question and aims. The online survey was comprised of four sections: background, awareness, opportunities and challenges. The researchers devised ten (10) questions for the background section in order to obtain information about each participant's background as well as information regarding the participant's knowledge of Green Information Technology. For the 'awareness' section, the researchers developed twenty-three (23) statements that were mainly concerned with design, safety, manufacturing and energy use, recycling, efficacy, and social interaction. For the 'opportunities' section, the researcher developed twenty-four (24) statements pertaining to financial opportunities, brand and reputation, human resources and shareholders, and environmental issues. The thirteen (13) statements for the 'challenges' section were mainly concerned with the issues of failure and cost. Participants also had the opportunity to offer additional opinions in a comment section in the last section of the survey.

For the awareness, opportunities and challenges sections a five-point Likert scale was used in each statement of the online survey to investigate how strongly the participants agreed or disagreed with statements (Bishop and Herron 2015; Hartley 2014; LaMarca 2011). The five-point Likert scale ranges from Strongly Disagree, Disagree, and Neutral, to Agree, and Strongly Agree. The online survey contained clear instructions at the top of the page and a progress bar along the bottom to offer feedback to users about their proximity to the finishing point. Furthermore, each page contained only three questions to minimize scrolling, and the concluding page thanked respondents for their participation. The Qualtrics platform was used for the online survey data collection, and 157 participants from Australia completed the whole survey and the response validity was 100% for this study.

Several studies (Boas and Hidalgo 2013; Couper et al. 2001; Dillman et al. 2009; Fleming and Bowden 2009; Issa 2013; Porter 2004; Sowmya Devi et al. 2014; Vaske 2011; Veredenburg et al. 2002) indicate that conducting an online survey provides contact between the participant and the survey via an online platform. Using an online survey saves time when compared to data downloaded with different formats including Word documents, SPSS, Excel spreadsheets, PowerPoint presentations among others, while the findings can be presented in numerous different formats such as tables, figures, and graphs. Calculations of mean and standard deviation based on the researcher's requirements can also be easily obtained.

Online surveys have many other advantages as they are less expensive, provide greater anonymity, are accessible and easy to manage, are less error-prone, and they eliminate the physical requirements of a paper and pencil survey, thereby confirming that online surveys are more sustainable compared with traditional survey platforms (Dillahunt et al. 2010; Dillman 2007; Dillman et al. 2009, 2010; Dillman 2017; Smyth et al. 2010; Toepoel and Dillman 2008). However, using an online survey in any study also has its disadvantages including technical problems, data security issues due to computer viruses and hacking, and incomplete surveys which can lead to a decrease in the response rate (Dillman 2007; Fan and Yan 2010; Heiervang and Goodman 2011; Issa 2013).

4 Results

Table 1 shows the number and percentage of online survey participants in terms of gender, age, and qualifications. The survey response rate was 100%; 49% of respondents were male, with 51% being female. The majority of respondents (12.7%) were aged between 25–30 years, while the highest percentage of respondents (27%) had a bachelor degree.

Furthermore, the online survey identified the devices used by the respondent to access the Internet. 27.22% of respondents use smartphone and 23.92% use a laptop (see Table 2).

We noted that most of the Australian users were first introduced to the concepts of Green Information Technology via news media, Internet and school with 26.39%, 22.68% and 14.5% respectively (see Table 3). The others were mainly introduced to the concepts from friends, family, childhood and general knowledge.

Furthermore, the online survey used statements to ascertain the Australian users' attitudes to their moral responsibilities toward the planet by examining whether exchanging their devices frequently will cause damage to our planet. Table 4 shows that 42.04% responded "Yes", demonstrating the respondents' awareness that changing devices frequently would cause damage to our planet.

The online survey examined Australian users' recommendations of ways to change the mindset of designers and users regarding sustainability. The survey

Table 1 Online survey statistics Australia

Number and percentage of online surveys completed	
Questionnaires distributed	157
Questionnaires returned	157
Response rate	100%
Gender (response and %)	
Male respondents	77 (49%)
Female respondents	80 (51%)
Age (response and %)	
18–20	3 (1.9%)
21–24	16 (10.2%)
25–30	**20 (12.7%)**
31–35	16 (10.2%)
36–40	16 (10.2%)
41–45	15 (9.6%)
46–50	19 (12.1%)
51–55	15 (9.6%)
56–60	15 (9.6%)
61–65	22 (14.0%)
Qualifications (response and %)	
Higher secondary/pre-university	29 (18.5%)
Professional certificate	22 (14%)
Diploma	18 (11.5%)
Advanced/higher/graduate diploma	6 (3.8%)
Bachelor's degree	**45 (28.7%)**
Post graduate diploma	11 (7%)
Master's degree	13 (8.3%)
PhD	4 (2.5%)
Others	9 (5.7)

Table 2 Devices used by Australian users

Answer	%	Count
Workstation	1.65	8
Tablet	16.49	80
Smartphone	**27.22**	**132**
PC	12.99	63
Netbook	1.03	5
Laptop	**23.92**	**116**
Desktop	16.29	79
Others—please specify	0.41	2

Table 3 How Australian users were first introduced to the concepts of sustainability and Green Information Technology

Answer	%	Count
School	**14.50**	**39**
Higher education	14.13	38
Internet	**22.68**	**61**
Books	5.58	15
Magazine	7.43	20
News media	**26.39**	**71**
Conferences	3.72	10
Others—please specify	5.58	15

Table 4 Australian users "Will Frequently Changing Devices Cause Damage to our Planet"

Answer	Response	%
Yes	**66**	**42.04**
No	28	17.83
Maybe	60	30.22
Not at all	3	1.91

concluded that via education, awareness and training (19%, 18%, 15% respectively), designers and users could change their mindset and attitude (see Table 5).

The survey asked the participants which of the following Green Information Technologies do you use, the majority of respondents indicated that are using social networking, cloud computing, and smart technology with 33.85%, 17.23% and 17.23% respectively (see Table 6).

A total of 157 valid responses were processed for the subsequent factor analysis. The analysis was conducted separately for the awareness, opportunities, and challenges questions respectively. The Cronbach's Alpha for awareness, opportunities, and challenges questions aspects were 0.951, 0.949, 0.909 respectively, indicating an excellent internal consistency of the items in the scale (Bravo and Potvin 1991; Connelly 2011; Gliem and Gliem 2003; Hill 2012). The Kaiser-Meyer-Olkin

Table 5 Australian users: "Can we Change the Mindset of Designers and Users Regarding Green Information Technology"

Answer	%	Count
Training	**15.02**	**96**
Education	**19.25**	**123**
Awareness	**18.31**	**117**
Workshop	7.67	49
Internet	13.93	89
T.V.	11.89	76
Social networking	13.15	84
Others—please specify	0.78	5

Table 6 Australian users: "Which Green Information Technologies do you use?"

Answer	%	Count
Virtualization	4.62	15
Cloud computing	**17.23**	**56**
Social networking	**33.85**	**110**
Smart technology	**17.23**	**56**
Blockchain	2.15	7
Drones	2.46	8
Robots	1.23	4
IoT (internet of things)	5.85	19
3D printing	0.92	3
AR (augmented reality)	2.46	8
VR (virtual reality)	4.92	16
AI (artificial intelligence)	4.00	13
Big data	3.08	10

measures of sampling adequacy of positive and negative aspects were 0.926, 0.909, and 0.858 respectively, indicating that a very good sample size was obtained for the purpose of analysis. The Bartlett's test of sphericity was highly significant for both awareness, opportunities, and challenges questions aspects, indicating that the items of the scale are sufficiently correlated for factors to be found (Blunch 2012; Burns and Burns 2008) (see Table 7).

Awareness aspects have three factors generated where the rotation resulted in a total of 62.891% of the variation from this group. The amount of variances explained by each of these factors is presented below (after the rotation attempt); the opportunities aspects also have three factors generated where the rotation produced a total of 60.305% of the variation from this group. The amount of variances explained

Table 7 Cronbach Alpha, KMO and Bartlett's test results

Group	Cronbach's Alpha	KMO sampling adequacy	Bartlett's test of sphericity
Awareness	0.951 (Excellent)	0.926 (Marvelous)	$\chi^2 = 2591.419$; df $= 253$ $p < 0.000$
Opportunities	0.949 (Excellent)	0.909 (Marvelous)	$\chi^2 = 2572.723$; df $= 276$ $p < 0.000$
Challenges	0.909 (Excellent)	0.858 (Meritorious)	$\chi^2 = 1292.405$; df $= 78$ $p < 0.000$

Table 8 Awareness, opportunities and challenges—total variance

Total variance explained—awareness						
Component	Initial Eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	11.409	49.603	49.603	11.409	49.603	49.603
2	1.830	7.955	57.558	1.830	7.955	57.558
3	1.227	5.333	62.891	1.227	5.333	62.891
Extraction method: Principal component analysis						
Total variance explained—opportunities						
1	11.146	46.444	46.444	11.146	46.444	46.444
2	1.963	8.180	54.623	1.963	8.180	54.623
3	1.364	5.682	60.305	1.364	5.682	60.305
Extraction method: Principal component analysis						
Total variance explained—challenges						
1	6.491	49.931	49.931	6.491	49.931	49.931
2	1.611	12.392	62.323	1.611	12.392	62.323
3	1.208	9.291	71.614	1.208	9.291	71.614
Extraction method: Principal component analysis						

by each of these factors is presented below (after the rotation attempt). Finally, the challenges aspects have three factors generated where the rotation produced a total of 71.614% of the variation from this group, the amount of variances explained by each of these factors is presented below (after the rotation attempt) (see Table 8).

To expand the regression measurements (i.e. slopes), the researchers carried out the factor loadings. The factor loadings of most of the items were adequately high and the one with the cleanest fact structured to be considered as important (Beavers et al. 2013; Costello and Osborne 2005; Preacher and MacCallum 2002). Several items under each factor were excluded where the factor loading was below 0.5 based on the Stevens (1992) rule of thumb for a sample size above 100.

Table 9 shows the group pattern matrix for the positive aspects. The pattern matrix revealed three awareness aspects namely: (i) e-Waste (ii) Eco-Friendly Materials and (iii) Design Efficacy.

Table 10 concluded that Green Information Technology awareness in Australia can assist businesses and individuals to encourage responsible recycling and disposal of e-waste, encourage the use of eco-friendly materials, and encourage designers to design with efficacy in their strategy. Moreover, the adoption of Green IT can reduce the pressure on Mother Nature and allow the next seven generations to enjoy the same lifestyle as we do.

Furthermore, Table 11 shows the group pattern matrix for the opportunities aspects. The pattern matrix revealed three opportunities aspects namely: (i) Environmental Value (ii) Productivity and (iii) New Opportunities.

Table 9 Rotated component matrix for the awareness aspects of Green IT—Australia

Rotated component matrix[a]			
	Component		
	1	2	3
Reduce consumption and waste of resources	0.821	0.281	
Produce less waste and toxins	0.717	0.418	
Have long life	0.716	0.271	0.246
Reduce carbon footprint	0.716	0.324	0.157
Reduce climate global warming	0.710	0.199	0.240
Reduce air pollution	0.697	0.307	0.212
Sustain environmental standards and rules	0.694	0.377	0.242
Have less packaging	0.679	0.206	0.257
Have good ethical principles	0.604	0.428	0.192
Use less raw materials	0.563	0.514	0.147
Have clean emissions	0.498	0.474	0.261
Reduce diseases and even death of humans	0.452	0.107	0.344
Use recyclable materials	0.350	0.810	
Use recycled materials	0.417	0.731	0.121
Use renewable materials	0.412	0.725	0.116
Use solar energy	0.123	0.724	0.264
Are easy to recycle	0.354	0.567	0.182
Use less energy	0.553	0.556	
Have successful production cycles	0.352	0.552	0.383
Are easy to add new software	0.158		0.854
Are easy to upgrade	0.180		0.851
Shifting the mode of consumption from personal ownership of products to provision of services	0.142	0.403	0.619
Have portability efficiency	0.277	0.399	0.608
Extraction method: Principal component analysis Rotation method: Varimax with Kaiser normalization			

[a]Rotation converged in 5 iterations

Based on the online survey outcomes for the opportunities aspects section, three new factors were generated; and these factors indicate that by business and individuals using Green IT there will be less harm brought to Mother Nature. Green Technology has massive environmental value from reducing carbon footprints, reducing emissions, reducing pollution and the reduction of raw materials usage. Green Technology also has a huge impact on productivity and new opportunities as it creates new

Table 10 The new awareness aspects of Green IT—Australia

Variables	Factor loading	New factor
Reduce consumption and waste of resources	0.821	*e-waste*
Produce less waste and toxins	0.717	
Have long life	0.716	
Reduce carbon footprint	0.716	
Reduce climate global warming	0.710	
Reduce air pollution	0.697	
Sustain environmental standards and rules	0.694	
Have less packaging	0.679	
Have good ethical principles	0.604	
Variables	**Factor loading**	**New factor**
Use recyclable materials	0.810	*Eco-friendly materials*
Use recycled materials	0.731	
Use renewable materials	0.725	
Use solar energy	0.724	
Variables	**Factor loading**	**New factor**
Are easy to add new software	0.854	*Design efficacy*
Are easy to upgrade	0.851	
Shifting the mode of consumption from personal ownership of products to provision of services	0.619	
Have portability efficiency	0.608	

jobs, improves working conditions, attracts quality employees and makes businesses unique (see Table 12).

Furthermore, Table 13 shows the group pattern matrix for the challenges aspects. The pattern matrix revealed three challenges aspects namely: (i) The rise of scandals and failure (ii) Upsurge in costs and rates and (iii) Escalation in competition and Environment policies.

The online survey generated new factors for the challenges aspects of the adoption of Green IT by businesses and individuals. These challenges should be taken into consideration during the adoption of Green IT. These challenges can be reduced with assistance of the government and other sectors by introducing specific regulations and rules in relation to cost, competition, and the risks of Green IT adoption. Moreover, to reduce the challenges among users and businesses by offering training, workshops, and university courses in order to raise the public awareness of Green IT adoption. Universities play a major role in transmuting societies' and students' critical philosophies and world opinions via tertiary education and research. Universities need to boost the students' awareness, especially in relation to their moral responsibility in promoting sustainable development, and guide them to a better, more sustainable future by using Green Technology in line to save Mother Nature; as human beings have been responsible for most of the damage done to the natural environment (Table 14).

Table 11 Rotated component matrix for the opportunities aspects of Green IT—Australia

Rotated component matrix[a]			
	Component		
	1	2	3
Reduce carbon footprint	0.830	0.169	0.184
Reduce emissions	0.792	0.242	0.228
Reduce pollution	0.763	0.386	0.158
Reduce paper usage	0.753	0.133	
Reduce Raw Materials usage	0.748	0.249	0.202
Reduce energy and water usage	0.676	0.266	0.226
Reduce health hazards	0.589	0.515	0.117
Increase green strategy	0.579	0.312	0.327
Improve corporate social responsibility	0.508	0.391	0.396
Increase cost-effectiveness	0.275	0.761	0.130
Reduce risk management	0.172	0.754	0.289
Increase productivity	0.133	0.713	0.304
Improve human rights	0.271	0.704	0.161
Attract quality employees	0.267	0.679	0.335
Increase triple bottom line—people, planet and profit	0.272	0.611	0.234
Improve social responsibility investing	0.388	0.578	0.337
Improve community investments	0.301	0.569	0.424
Increase efficiency	0.360	0.505	0.112
Differentiate businesses	0.143		0.739
Attract new opportunities	0.215	0.233	0.737
Create new jobs		0.303	0.716
Enhance reputation	0.283	0.197	0.689
meet stakeholder expectations	0.171	0.297	0.588
Satisfy customer needs	0.204	0.433	0.493
Extraction method: Principal component analysis Rotation method: Varimax with Kaiser normalization			

[a]Rotation converged in 6 iterations

In conclusion, the new awareness, opportunities and challenges aspects of Green IT adoption by businesses and individuals in Australia will reduce the carbon footprint and damage to the natural environment, conserve raw materials for the next seven generations, and ensure commitment to mitigating environmental problems.

Therefore, there is a call to action for businesses and individuals, including Information systems business, educators, researchers and users, all of these must be made to adjust their mindsets and level of thinking to recognize the impact of IT. Our planet is suffering, and we need to immediately address the issues of recovery, raw material supply and energy consumption, as there is no Plan B for our planet (Issa et al. 2017).

Table 12 The new opportunities aspects of Green IT—Australia

Variables	Factor loading	New factor
Reduce carbon footprint	0.830	*Environmental value*
Reduce emissions	0.792	
Reduce pollution	0.763	
Reduce paper usage	0.753	
Reduce Raw Materials usage	0.748	
Reduce energy and water usage	0.676	
Increase cost-effectiveness	0.761	*Productivity*
Reduce risk management	0.754	
Increase productivity	0.713	
Improve human rights	0.704	
Attract quality employees	0.679	
Increase triple bottom line—people, planet and profit	0.611	
Differentiate businesses	0.739	*New opportunities*
Attract new opportunities	0.737	
Create new jobs	0.716	
Enhance reputation	0.689	

5 Discussion and New Findings

This chapter aims to examine the awareness, opportunities and challenges of Green IT adoption by businesses and individuals in Australia. For this study 157 Australian participants completed an online survey by providing their perspective and perception regarding Green IT adoption. The outcome of the online survey is that it successfully addressed the aims and objectives of the study as it generated three new factors for the awareness, opportunities and challenges sections. The new findings from this study are presented in Fig. 4, as the Australian participants indicated that Awareness factors are mainly focused on E-waste, Eco-Friendly Materials and Design Efficacy, while the Opportunities are mainly focused on Environmental Values, Productivity and New Opportunities. On the other hand, the Challenges are The Rise of Scandals and Failure, Upsurge in Cost and Rates and Escalation in Competition and Environment Policies. These new factors provided evidence that the Australian public is concerned with the suffering of Mother Nature, and they are keen to use Green Technologies as adopting and using these technologies will reduce the current impact from carbon emissions, waste, global warming, pollution and energy usage.

Using these technologies, will create new opportunities and increase productivity among users.

However, the adoption and implementation of Green Technologies by individuals and businesses may lead to scandals and failures, increased costs and rates and increase competition and environment policies, therefore, in order to include Green Technologies in our daily life, awareness, training, teaching and education are all needed to minimize these negative aspects with the support of local, state and federal

Table 13 The new challenges aspects of Green IT—Australia

Rotated component matrix[a]			
	Component		
	1	2	3
Increase scandals by perceived environmental irresponsibility	0.823		0.283
Increase transaction failure due to environmental liabilities	0.800	0.240	0.128
Increase marketing failure by perceived environmental irresponsibility	0.799	0.204	0.195
Increase fraud (including environmental actions and environmental compliance failures)	0.795	0.309	
Increase governance failure (including environmental actions and environmental compliance failures)	0.782	0.326	−0.134
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	0.770	0.315	
Increase supply chain crises due to suppliers' environmental problems	0.695	0.340	0.285
Increase security and systems failures caused by environmental problems	0.646	−0.134	0.395
Increase interest rates	0.268	0.827	0.170
Inflate costs	0.131	0.821	0.155
Increase insurance crises due to environmental disasters	0.503	0.619	0.306
Increase competition for and cost of raw materials	0.106	0.181	0.852
Increase number of new regulations including environmental		0.207	0.797
Extraction method: Principal component analysis Rotation method: Varimax with Kaiser normalization			

[a]Rotation converged in 6 iterations

governments and organizations, to change users' mind-set and behaviour by integrating and amalgamating Green Technologies in their agenda (Hardin-Ramanan et al. 2018; Issa et al. 2017; Issa and Issa 2019; Issa et al. 2015; Varela-Candamio et al. 2018; Wang et al. 2015).

This change will assist our environment and our planet as it is up to us to take care of our planet for the next generation, since there is no Plan B for our planet (Issa and Isaias 2015a). Businesses and individuals must take responsibility for their actions and recognize their impacts on our planet. By adopting Green Technologies in everyday activities, people's lifestyles can become more sustainable and more eco-friendly.

Table 14 The new challenges aspects of Green IT—Australia

Variables	Factor loading	New factor
Increase scandals by perceived environmental irresponsibility	0.823	***The rise of scandals and failure***
Increase transaction failure due to environmental liabilities	0.800	
Increase marketing failure by perceived environmental irresponsibility	0.799	
Increase fraud (including environmental actions and environmental compliance failures)	0.795	
Increase governance failure (including environmental actions and environmental compliance failures)	0.782	
Increase litigation and compliance breaches (including environmental actions and environmental compliance failures)	0.770	
Increase supply chain crises due to suppliers' environmental problems	0.695	
Increase security and systems failures caused by environmental problems	0.646	
Increase interest rates	0.827	***Upsurge in cost and rates***
Inflate costs	0.821	
Increase insurance crises due to environmental disasters	0.619	
Increase competition for and cost of raw materials	0.852	***Escalation in competition and environment policies***
Increase number of new regulations including environmental	0.797	

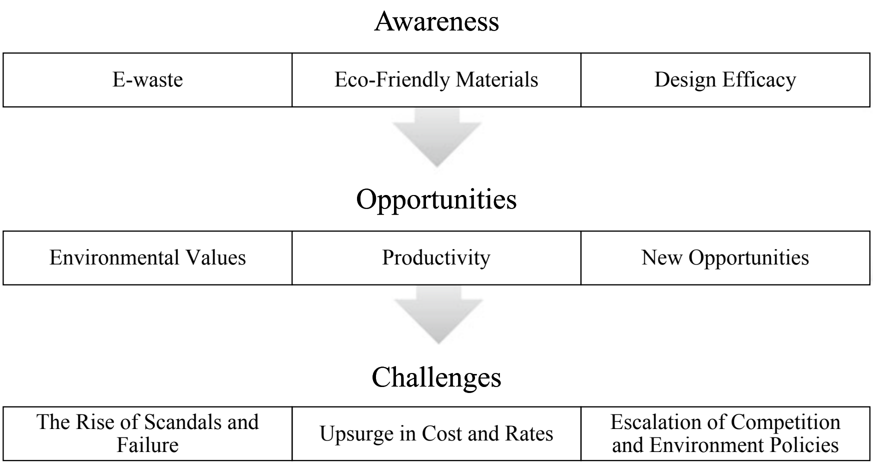

Fig. 4 New factors for awareness, opportunities and challenges of Green IT adoption by businesses and individuals in Australia

Lastly, all stakeholders, including businesses and individuals, must contribute to the transition to a more sustainable world by using Green Technologies. There must be an urgent call to all businesses, individuals, and universities to raise their moral responsibility in contributing to sustainable development and guiding others on the path towards a sustainable future.

Finally, this chapter makes a significant contribution to the current literature, especially regarding the issue of Green Technologies adoption from the perspective of awareness, opportunities, and challenges within Australia. We need to act swiftly to eliminate current and future problems (Issa 2017). Finally, in the future further research will be carried out to examine more diverse groups of stakeholders from other countries to strengthen the research findings.

6 Conclusion

This chapter presents the findings from an online survey conducted with 157 participants, who were requested to offer their attitudes on Green Technologies adoption from the perspective of awareness, opportunities and challenges. The study generated three new factors for each aspect of awareness, opportunities and challenges in an Australian context. These factors shared a new perspective how using Green Technologies will assist businesses and individuals to become more sustainable with the most important aspect being to reduce the impacts of technology (i.e. waste, energy, pollution and others), on Mother Nature. Therefore, businesses and individuals should act now to conserve and protect our planet, especially for the next seven generations, by integrating and adopting Green Technologies in their strategies to make our life and our planet more sustainable, ecologically and environmentally. This study was limited to Australia; therefore, in the future the researchers will examine other countries to compare and contrast the stakeholders' awareness, opinions and attitudes to Green Technologies adoption.

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Designing Solutions for the Commons

Davide Fassi and Francesco Vergani

Abstract The regeneration of the commons occurs through direct involvement of groups of people who interact closely with spaces, and who aim to improve the overall quality of life and experiences connected with those spaces. This process starts from an increased consciousness towards places that do not belong to the private realm but are public or can potentially be used by the society Revealing the commons means being aware of the potentialities of these "hidden places" to not only connect people with them, but for people to also create a previously unknown sense of community and ownership among themselves. By showing best practices developed by the Polimi DESIS Lab in the city of Milan and its surroundings, this paper reveals: how design relates to this process; the relationship between the time of involvement and the effectiveness of the results the short- and long-term impacts of these interventions; and the legacy of the regeneration, including both failures and successes.

Keywords Commons · Social innovation · Public spaces · Community · Resilience · Neighbourhood · Activist

1 About the Commons and Design

The increased focus on the management of the commons is presenting new challenges in the discipline of design, both in the professional and the research fields. The term *commons* is being used primarily to identify different sorts of common goods and, in order to understand these different types, it is necessary to draw a framework around the meaning of the term as it has been used over the years. The feature that unites these different groups is the presence of both a tangible and an

D. Fassi (✉) · F. Vergani
Design Department, Politecnico di Milano, Milan, Italy
e-mail: davide.fassi@polimi.it

F. Vergani
e-mail: francesco.vergani@polimi.it

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intangible network, managed by different communities of people and administrations that, through collective actions guided by design-oriented practices, put effort into maintaining these goods for community use. While on the one hand people use traditional management infrastructures, such as administrative and state procedures on the other they are developing new forms of participation, based both on the use of digital platforms and network resources, and on the transfer of information, knowledge and skills. After a brief introduction about the meaning of the term commons and its use since the 20th century in social, ecological, cultural and urban contexts, this chapter focuses on the framing of the relations between the design discipline, including educational, research and practice outputs, and the commons.

"The International Association for the Study of the Commons (IASC)" refers to the commons as to a broad set of resources, both natural and cultural, that are shared by many people. The term *commons*, from *common land*, is derived from a medieval English context to indicate a portion of land owned or managed collectively by a certain number of people (Neeson 1996). The term was subsequently introduced into the scientific debate by the American ecologist and philosopher Garrett Hardin (1915–2003) who first used it in the meaning of a *shared resource* in his famous essay "The Tragedy of the Commons" in the journal *Science* (1968). He wanted to make readers aware of the overpopulation of societies and the logic behind excessive use and consequent degradation of common goods in terms of economic growth and environmental protection. The theory developed by Hardin was originated by the British economist William Forster Lloyd (1833), who used a hypothetical example of the effects of overgrazing caused by unregulated grazing on common lands in Great Britain and Ireland. From this concept, Hardin (1968) developed a series of critical considerations regarding the free sharing of commons, believing that freedom in the management of common goods inevitably leads to neglect, excessive consumption, and ruin of shared resources. As a solution to the disastrous vision of consumption in the future of the planet's natural resources, Hardin (1968) theorized the need for a structured intervention both through government regulation and through the establishment of private property regimes for the management of the commons. Although the theory resonated in subsequent years, highlighting the issue of ecological challenges in terms of pollution and progressive consumption of natural resources, Hardin's intervention was criticized for limiting the importance and interest of communities of individuals in the management and administration of shared resources (Axelrod 1984; Ostrom 1990). Hardin's pessimistic perspective was later contradicted by American economist Elinor Ostrom (1933–2012) and her studies based on identifying the active role of public communities in decisions that influence the production of public goods and services. Her research, developed in the book *Governing the Commons: the Evolution of Institutions for Collective Action* (1990), led to the identification of communities of people and citizens as an essential element for good management of the commons, avoiding their administration being entrusted to government authorities or economic market rules through top-down approaches (Wall 2005). These local communities exclude the participation of external interests single foreign and private individuals, and regulate the use of goods by members of the local community through the identification of equal and interdependent users and non-exclusive rights (Feeny et al. 1990). Unlike the idea theorized by Hardin, Ostrom was able to stimulate a community development policy "*that played a critical role as a major intellectual critique of the dominant model that privileged property rights as the core solution to collective action problems*" (Benkler 2013, p. 4). In the definition of her work, the economist provided an analysis conducted on different case studies of natural resources of small and medium scales, identifying eight *design principles* as actions in which "*a group of principals can organize themselves voluntarily to retain the residual of their own effort*" (Ostrom 1990). These principles were used as "*a way to distinguish among robust, fragile, and failed institutions*" (Ostrom 1990, p. 181) by testing the success of institutional arrangements in sustaining a particular Common-Pool Resource[1] (CPR) and gaining the compliance of generation after generation.

Studies on the commons and their management have experienced substantial growth and development in recent decades (Van Laerhoven and Ostrom 2007). As addressed and theorized by the works of Hardin (before) and Ostrom (now), the most well-known and fragile types of commons, which require constant regulation, are any shared and unregulated natural resources around us: forests, fisheries, atmosphere, air, water and anything else linked to the earth's natural elements. The urgent need to preserve these CPRs, through constant community management and protection actions, is correlated to their status of resources as limited by time. However, what unites all the different types of commons is the idea that they are "*shared resources that are vulnerable to social dilemmas*" (Hess and Ostrom 2006, p. 13), i.e. common goods that generate potential problems and social dilemmas mainly due to excessive use of the available resources. In the last twenty years, the term commons shifted to a broader set of domains, such as knowledge commons, digital commons, urban commons, health commons, cultural commons, and others. Generally, commons are complex institutions in which land and other resources are used collectively by self-governance and rules that are self-restrictive and self-sanctioning (De Moor 2015). Therefore, today's literature suggests different thematic groups of commons: the first, as previously mentioned, is attributable to traditional research with its main focus on understanding the role that communities of people and institutional agreements play in supporting and managing natural resource commons in various sectors such as agricultural or fisheries (Ostrom 1990). Empirical studies on the commons demonstrate that, despite various social problems, communities themselves are able to create, manage and support natural resource commons through collective action practices, thus identifying other forms of organization besides the market, governments and private associations (Wall 2005; Marttila et al. 2014). This group, attentive to the problems of the consumption of natural goods, is founded on the conception

[1]Common pool resources (CPRs) are characterized as resources for which the exclusion of users is difficult (referred to as excludability), and the use of such a resource by one user decreases resource benefits for other users (referred to as subtractability). Common CPR examples include fisheries, forests, irrigation systems, and pastures. Retrieved June 17, 2019, from https://www.oxfordbibliographies.com/view/document/obo-9780199363445/obo-9780199363445-0011.xml#obo-9780199363445-0011-bibItem-0002.

of the commons as something concrete, tangible and subtractive (CPR) that requires continuous monitoring by humans and their organizational structures.

Thanks to digital systems that allow immediate exchange of information, which emerged through the creation of the Internet in the mid-90s, it has been possible to define a new type of commons identified in the transposition of collective actions and knowledge into a new ecosystem based on a web's digital archive (Hess and Ostrom 2006). These types of commons, completely accessible and open to democratic management, are mostly cumulative and reusable intangible resources that, unlike tangible and natural goods, cannot be exhausted or consumed, and one person's use does not reduce other people's benefits (Marttila et al. 2014). This group includes all cultural and intellectual commons such as literature, music, art, design, film and all those elements for the transmission of knowledge that are maintained by a community of contributors in the form of encyclopedic knowledge on online platforms which any person can freely access without regulation by a defined authority (Huberman et al. 2009). This type of commons has now overcome cultural boundaries by building a framework of knowledge that is extremely important for most digitally active individuals. Peer-to-peer management allows the creation of a self-governed social hierarchy where individuals cooperate democratically within the development and maintenance of digital content, avoiding a top-down approach that would limit their communicative potential.

A more recent trend identifies in the commons a store of shared resources that is not limited to the management of natural elements and the dissemination of knowledge but is also linked to the entire urban heritage lived by communities of citizens. These *urban commons* are "*resources [that] range from local streets and parks to public spaces to a variety of shared neighborhood amenities*" (Foster 2011, p. 57) and, just like other common resources, are non-subtractive elements. Throughout the years, there have been several successful practices and extensive literature about the interaction between communities and commons, and their role in the governance of them has been explored (Ostrom 1990). Local communities are interacting more and more with the urban fabric through solutions that innovate the sociotechnical system, dealing with social problems and with the regeneration and activation of physical and social commons (Manzini 2019; Fassi 2017). It is necessary to start by thinking that living in contemporary cities means being part of sharing practices labs, which are in a way bringing us to new forms of economies and collaborations. Nowadays, cities are recognized as laboratories for sharing good practices with a central role in creating a new economy (Smorto 2016). Even if most of the time, these labs look as though they are composed of a multitude of individual projects, they have the potentialities to work in the long term, interacting together through an open-ended structure, and resulting in a system where components are related, influence each other and are able to expand (Hillgren et al. 2011). These systems are a relational concept that deals with formal and informal groups of people who have several different ways of relating with the commons (Star and Ruhleder 1996).

This chapter attempts to observe and analyze possible relationships between design/communities/ commons, dealing mainly with the city of Milan and its spaces, and including the applied research done by the authors within the Polimi DESIS Lab[2] at the Politecnico di Milano in Italy. The analysis will explore the identification of four main categories: "Living Streets", "Social Districts", "Public Squares", and "Community Gardens".

2 Living Streets, New Forms of Communities-of-Place: "Trentami in Verde"

"Trentami in verde" is a collective project developed by four associations and informal groups (Genitori AntiSmog, FIAB Ciclobby Onlus, Nolo Social District, Core—Lab) together with the Municipality of Milan (Italy) and architect, Matteo Dondè. It is an experiment in transforming part of a neighbourhood, close to a public primary school, with unsafe sidewalks, unauthorized parking areas and high-speed traffic, into a "living street" (Gehl 2013) with safer paths, a public square, playgrounds and rest areas with particular emphasis on plants and green areas. The project started as a test from April 4th to July 7th, 2019. Then the Municipality decided to extend it until Dec 31st, 2019 with the aim of letting it become a permanent solution (Lydon and Garcia 2015). It was based on the expertise of: the "Genitori AntiSmog" association in developing projects like this in the past; a very active local group called "Nolo Social District" made of active citizens who help each other and develop solutions to improve the quality of life of their neighbourhoods; "Fiab Ciclobby Onlus" a non-profit organization which promotes the use of bicycles in the cities; and Core-Lab, a network of professionals who perform applied research projects about neighbourhood well-being and urban ecosystems.

"Trentami in verde" was designed through a proposal presented in the call for the "2017 Participatory Budget of the city of Milan" by a spontaneou sly formed group of activists related to the Nolo Social District.[3] The project "Mobì" did not obtain the funding but attracted the interest of the Municipality of Milan—Mobility Department, which at the end of 2018 created a working table with the "Genitori Antismog", "FIAB Ciclobby" and "Core- Lab". The roundtable discussion developed one of the six components included in the "Mobì" project, about a system of interventions to slow down car traffic and increase the safety of cyclists and pedestrians through light and reversible interventions that could give rise, after a sufficient period of experimentation, to definitive solutions in the long term. Thanks to an intervention to reduce the section of the two-way carriageway in the "via Rovereto", an interstitial space 200 m × 1 m was obtained, which was fitted out with potted plants and flower beds and ran alongside a large sidewalk of over 3 m, set up with tables and benches to create a new meeting place. The entrance to "Trotter Park", a historic school park accessible to citizens outside of school hours, was previously used for

[2]More details about the case studies quoted in this text can be seen at www.desis.polimi.it.

[3]Nolo is the acronym for "North of Loreto", where Loreto is a big square at the threshold between the city centre of Milan and the first belt of suburbs.

unauthorized parking. This has been improved by placing bicycle racks, flower beds and potted plants at the entrances to the park to prevent access to cars and recreate a real square.

The two spaces involved were also the subject of an interesting street-art intervention that saw the collaboration between the inhabitants of the neighbourhood, and a professional and amateur artist. The placement of urban furniture has a double aim: to create hospitable places for people to gather, and to prevent illegal parking. The reduction of the size of the street was to reduce the speed of the cars and to make them move smoothly with the bicycles. The potted plants and garden beds were to help the people envision how that place could be transformed into a green belt.

The project was done in a collective way with direct engagement of the local communities from the beginning (Fig. 1). A building site open to everyone was accessible for three weeks to set up the urban furniture and create opportunities of social cohesion among the participants. The Nolo neighbourhood is composed of people from different countries and backgrounds and this mix of behaviours is mirrored in the use of the "Trentami in verde" project. The tables and benches are used for various purposes in different parts of the day: from playing board games to the knitting club; from convivial lunches/dinners to informal work meetings; from small group activities to large gatherings of cyclists. This has led to a stronger sense of the new place, with increased care about the project, due to constant maintenance by a group of volunteers who spontaneously started to clean the streets, water the plants, engage other people and tell everyone about the project. Many events have been organized in the new public square and not only by the locals, such as concerts, dance performances and public speaking. Focus groups have been organized by the associations involved to get feedback from those who are positive about the project and those who are against it. That was the opportunity to collect information to adjust the project for the future. Potted plants have been "adopted" by the children in the primary schools and by some citizens who are ensuring their maintenance. Also, people continue to make spontaneous donations of pots, plants, paint and garden tools to the project.

"Trentami in verde" is an example of a community of place, and a group of previously unacquainted people who have come together thanks to a shared interest

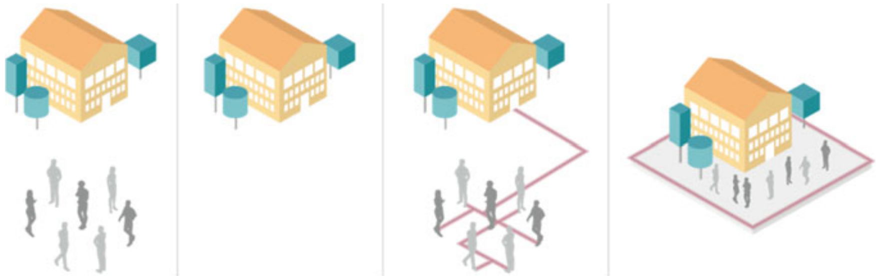

Fig. 1 Potential commons, community to be developed

Fig. 2 Street painting in via Rovereto (Nolo, Milan). Photo by the authors

in a problematic piece of land in order to transform it into a liveable one. The features people bring to places and the structure of their experiences with places (Cuba and Hummon 1993) define their identification with them. The time they spent codesigning the output, building the urban furniture, painting the sidewalks and maintaining the site week by week, helped the volunteers to connect with this common, and to give it a new face (Fig. 2).

3 Social Districts, Place-Related Social Forms: "Nolo Social District"

The "Nolo Social District" (NSD) is a group of people living in the Nolo district of Milan, who meet online on a private Facebook group to get to know each other, solve small daily issues (from the choice of the best restaurant in town to the most competent carpenter, from cat-sitting to lost and found objects). This is intended to improve their quality of life, to help them feel safer and to create a network to support their initiatives. The NSD is composed of 8,500 people (August 2019) out of the 25,000 people who live in the area and come from more than 40 different nationalities as a result of different waves of migration over the past decades. A social district can be considered as a larger version of a "social street" that has its roots in Italian culture, since this phenomenon came to life in 2013 in Bologna where the first social street was founded. Nowadays there are more than 450 in Italy, and some municipalities (like Milan) started to recognize the phenomenon by including them in an official register and allowing them to apply for public funding. Living in the public spaces, getting to know each other, sharing a "family feeling" even when you are away from your private space, and counting on each other help are just some of the features of being part of a social street. Facebook is used as a means of communication, while debate and organization of activities are usually done offline. Moving from virtual to real is the added value of the social district. People not only chat online but they often meet together and carry out actions not only to solve their own issues but to improve the quality of the public spaces and increase social cohesion. Neighbours use it to organize themselves in small groups of interest: with no charge for any of the organized activities or proposals put forward by the group; no fixed structure in the organization of single groups; and inclusion of differences (languages, nationalities, etc.).

The NSD was founded when the neighbourhood itself was initiating a social and urban change. The urban transformation of the area started to emerge in 2016: redevelopment of disused spaces into places of innovative services and the spontaneous gathering of the inhabitants around different online and offline realities. The spontaneous and voluntary social activities, generated (and continue to generate) good practices and a sense of community (McMillan and Chavis 1986), thus preserving the popular character the area had before it was called Nolo. The vacant shops, the municipal market, the residual spaces and the abandoned green areas, are all recipients of micro-planning solutions that host services, actions, and functions to support solutions of: placemaking and tactical urbanism (Markusen and Gadwa 2010); adaptive space reuse (Camocini 2016); short-term and long-term urban temporary solutions (Fassi 2012) for an improvement in the quality of spaces (public and otherwise); and as a consequence, more active social interaction (Zhang and Lawson 2009).

Relationships between the community of NSD and the potential commons are rooted in the way the NSD is organized. The creation of sub-groups of interest is strictly connected to the use of spaces in the neighbourhood where the activities are to occur: parks for jogging ("Nolo Run"); sidewalks for breakfasts ("The Saturday morning Nolo Breakfast"); and urban furniture to provide workshops ("Nolo Plastic Free", "Lanolo"—knitting club"). Citizens transform potential commons by directly enacting them, suggesting different uses, and adding quality through being there and protecting them from misuse.

As designers, the Polimi Desis Lab had the chance to encounter this vibrant neighbourhood by reinforcing the connections among people and places with an interdisciplinary (space and service design) opportunity-centred approach (Bertola et al. 2016), optimizing the existing proactivity of the neighbourhood community and the widespread presence of artists. Several activities were carried out including: (1) "Arnold—Art and Design in Nolo district" (June 2017), a two-day event resulting from a 4-month design process with 50 students, 22 local artists and 50 citizens, to display 11 exhibitions in unconventional places (i.e. bakeries, parking lots, groceries etc.; (2) "Design + Eat = Spaces" (April 2018) was about the renewal of the municipal indoor market with a focus on the relation between food and space, with several codesign sessions with people from NSD; (3) Participation in "Exploratory Survey" (June 2018) aimed at acquiring expressions of interest for the realization of projects, events or initiatives of a social, cultural or recreational purpose by temporarily granting use of spaces within Municipal Markets; (4) "Living (Market) Lab" (2019)

Fig. 3 Potential commons/existing subgroups of a community: intertwining

designed the scenario in which the Market could become a Living Lab and tested some of the solutions during "Mercato Animato", a set of events funded by the municipality to help the associations develop social activities besides the commercial ones already in the Market (Fig. 3).

The activities developed from a view of the whole neighbourhood ("Arnold") to a more specific focus on the potentialities for the local market to become a new centre of social activities. This was due to a strong need for its refurbishment because of a lack of shops, the poor condition of the building, and a decrease in customers despite its long tradition as a commercial point (it was opened in the 1930s) and its recognizability as a landmark due to its unique shape. The market is a potential common that sparks the interest of local existing groups (mainly NSD and other associations) to give it new life. This interest is being translated into real projects thanks to the municipality who is opening calls for space rentals not only for shops but also for non-profit organizations (Fig. 4).

4 Community Gardens, Generating New Urban Commons: "CampUS"

"CampUS—incubation and implementation for social practices" was a selected project to be funded by "Polisocial", the social responsibility programme of the Politecnico di Milano in 2014. The Polimi DESIS Lab at the Design department, together with researchers in Architecture and Urban studies, Management and Engineering, applied to the Polisocial call with an applied research project aimed at creating community gardens, a web tv and an mobile pavilion to host association events for the Bovisa neighbourhood located in the northern part of Milan, close to one of the main campuses of the Politecnico di Milano. The idea behind the project was to export the expertise of the academics outside the boundaries of the campuses to meet the needs of citizens by implementing some projects to help improve their quality of life. Interdisciplinarity was guaranteed by the three departments involved, which shared the same design approach based on local community being at the centre

Fig. 4 Codesign activities in the municipal market. Photo by the authors

of the process. The three main goals (gardens, pavilion and web tv) were achieved through a continuous co-creation process with people from the neighbourhood. It started by engaging them through a call for action, then went on to co-design solutions in several workshops, develop prototypes with the help of postgraduate design students, and then build the final output through co-construction activities. Those outputs were part of a design "toolbox", a set of tools to replicate the process (and the outputs) in other contexts in order to reinforce the idea of having an exportable model of social engagement and cultural exchange between communities of citizens and the university.

"CampUS" lasted two years and involved more than 50 local associations and almost 2,000 people. Most of the activities were related to public spaces. A 5,000 m^2 community garden was established in an abandoned green area owned by the municipality of Milan and the mobile pavilion travelled between three public parks in the neighbourhood. Within this framework, the activities related to community gardens were an interesting example of how an existing community that was *not* related to the neighbourhood expanded through the inclusion of local citizens, in order to be connected with a potential local common through design activities organized by the Polimi DESIS Lab (Fig. 5).

Taking part in community gardens helps to build or revitalize a sense of community among neighbours (Shinew et al. 2004) and plays an important part in bringing people closer ('Yotti' Kingsley and Townsend 2006). When campUS started, the engagement of local people was the most challenging issue, since there was no strong network of associations or groups around the abandoned green area. Instead, the social canvas

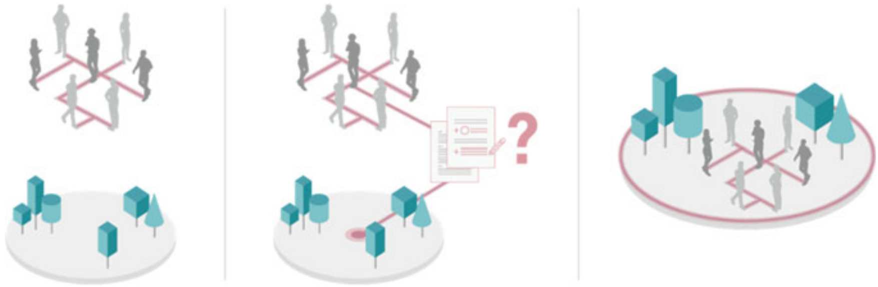

Fig. 5 Potential commons/existing community not related with it

was mainly made up of individuals or families who were not well connected with each other due to the lack of places in the area where they could gather and socialize. The green area was given through a public tender to “NoveXNove”, a non-profit association dealing with projects for human well-being. They asked the Polimi DESIS Lab to help them create a community around the garden project and to co-design the spatial layout and services to support it. Community engagement was through a “door-to-door” action—an advertising campaign with flyers put in the mailboxes of the residential buildings and banners placed in the area’s main shops. The people who answered the call were engaged in the Lab’s design workshops on the Politecnico campus and on site in the green abandoned area. The connection between the citizens and the area was the starting point for regenerating the commons. The potentialities of the abandoned area were only revealed to the local people when an external actor got involved (the Polimi Desis Lab) and showed them, through design activities, how that place (which had been used mainly as a garbage dump) could be transformed into a place for growing vegetables and social gatherings. The link between the existing community (“NoveXNove” association), local individuals and the commons was established after the participatory activities ended, when, collectively, they started to build the community garden (Fig. 6). Five years after the beginning of the “CampUS” project, we see today how the garden has become a landmark for the neighbourhood, where more than 50 families have their own piece of land to cultivate, primary and middle schools take care of the common areas through extra school activities, and events are regularly held that promote and spread the values of the commons.

5 Discussion

As seen from the projects presented in the chapter, the actual conception of commons has shifted from natural elements to digital domains and physical urban spaces, conveying knowledge, legacy and culture through communities of people. Despite Hardin’s now outdated theory of “The Tragedy of the Commons” (1968), people play a substantial role in governing CPRs and public resources as they are the primary

Fig. 6 "Campus" community garden co-creation process. Photo by the authors

and essential element that benefits from a common administration of goods. Whether the commons are subtractive or non-subtractive elements, they are something for everyone's use and consumption that still need to be supported and monitored by a group of people able to create and manage a process of maintenance over time. The three main categories of commons identified by the projects led by Polimi DESIS Lab reinforced the idea that people can overcome social problems and issues by breaking down cultural boundaries, as well as age and social differences, through collective actions. This regeneration process aims to create a sense of community (conceptual and physical) between different people and spaces that works thanks to a bottom-up process set in motion by actors (citizens, administrations, scholars) and guided by design-oriented practices.

In some case studies, universities (in this case, the Politecnico di Milano) have played a key role in activating, connecting and structuring relations among people and between people and places. Although sometimes this process has been difficult to establish in some contexts, people have almost always responded positively to the activities, participating in the process and benefiting from the results in terms of personal and community satisfaction. The projects outlined in the chapter have received a positive response from the citizens. It is interesting to see how people react when questioned about issues they understand to be potentially effective in improving their condition. Working closely together, communities find themselves acting productively, establishing that proactive behavior necessary to overcome a lack of possibilities for the future. All the actions and tools conveyed by scholars through co-design sessions, workshops, performances and temporary events, are indispensable devices to be considered in the process of network activation between different communities. In the examples, local networks of people initiated multiple "micro-spaces of daily life" (Sassen 2004) and transformed potential commons into real ones, which in some cases are still used and now shared among different communities. From the development of community gardens and public squares to the growth of relations within an urban district and its commercial areas, design discipline and its processes can improve communities' quality of life by reinforcing the connection between people and public spaces, giving hints and tools on how to manage commons and developing an effective administrative path over time.

From the projects presented in the chapter it is clear that there is a need to outline three main areas, or series of practices, for further development on the role of design within' communities:

(1) Breaking down barriers

Communities within cities still need to embrace a new conception of the surroundings, trying to overcome issues and problems by benefiting from good design practices. It is necessary, as researchers, to test and prototype activities with/between different groups of citizens to give them hints and tools on how to include common goods in the urban context. As previously seen, tactical urbanism can be used effectively as one of the revival methods to activate the social and environmental fabric by testing long-term solutions in urban context-based projects. All the activities that can be trigger into urban spaces have to be crafted through the construction of a network composed of local administrations, designers and citizens, aimed at strengthening the lacking sense of community. It is necessary to reduce the distances between people, and design practices can be helpful in breaking down the invisible barriers that still exist in many urban contexts.

(2) Universities as a link between people and places

Nowadays, education and research can improve the number of activities that occur between the universities and the public realm (municipality, local communities, informal groups of people) in order to explore new ways of spreading the knowledge from academia and to prompt new forms of social innovation. That is possible by focusing more on the "third mission" of universities with the aim of producing social values by fostering well-being and civic awareness through the use of methods of effective cultural, social and educational impact. It can be useful to define a package of actions and practices that have the potential to extend and grow within the urban context through open-innovation ecosystems.

(3) Agonism as a way to boost innovation

As previously seen, working with communities means entering in a system that deals with different actors, activities and spaces. In the envisioning process for developing context-based projects that offer solutions and implement practices for the wellness of the whole community, it may be useful to motivate citizens by the establishment of a constructive debate on real problems and possible solutions. Common areas within the urban fabric can be seen as an *agorà*—or a public square—in which a political encounter can be generated through the use of agonism (Mouffe 2007; Arendt 2013), fostering innovative solutions and reinforcing the practices of participative design.

Universities can focus more on finding practices and solutions to stimulate social innovation processes, and activating communities in a resilient way by understanding and expressing different visions and voices for future well-being. Communities still need to be helped and guided in discovering these "hidden places" in the city to be essential urban patterns with a dormant potential for development, as well as an agonistic attitude able to stimulate people's social behaviours and interests in the administration of the commons.

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Design for Sustainability—Collaborative Learning and Dissemination at IIT Guwahati, Assam

Ravi Mokashi Punekar, Sharmistha Banerjee, and Pankaj Upadhyay

Abstract In India, the Indian Institutes' of Technology (IIT's) are recognized as autonomous Higher Education Institutions (HEI's) of national importance. They have played a stellar role in planning and development of state of art technical educational curricula that address priority areas of contextually relevant developing needs. These institutions anchor the role of 'Influencers of Change' for other technical institutions across the country that outline their curricula following the IIT models'. Collaborations at national and international levels with HEI's form a means in updating and strengthening academic and research exchange. IIT Guwahati (IITG), Department of Design (DoD), recently participated as a partner institute on one such international collaborative project titled 'Learning network on Sustainability International (LeNS.in). The project aimed to develop and promote courseware on Design for Sustainability with thirtytwo leading international schools of Design participating on this global project. This course is now formally included in the curriculum of the Design program at IITG and is offered to graduate researchers and undergraduate students of DoD. In this chapter, we present DoD's role in introducing and developing the courseware on Design for Sustainability (DfS). The course covers concepts, context sensitive applications, methods and their assessment appropriate for Indian context. Theoretical framework on sustainability are introduced while undertaking field-based projects. These inputs form an integral and important contribution in training the next generation of designers in the design and development of products, services and systems (PSS) that are contextually appropriate and address needs of development. Case examples of classroom projects undertaken during the coursework on Design for sustainability are presented. Introducing DfS formally into the Design education curriculum is timely and significant considering the influence it

R. M. Punekar (✉) · S. Banerjee · P. Upadhyay
Department of Design, Indian Institute of Technology Guwahati, Guwahati 781039, Assam, India
e-mail: mokashi@iitg.ac.in

S. Banerjee
e-mail: sharmistha@iitg.ac.in

P. Upadhyay
e-mail: pankaj.upadhyay@iitg.ac.in

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may have on training manpower required in the growing field of Design and Design Education in India.

Keywords Design for sustainability (DfS) · Design education in india · Collaborative learning · Field case studies · Design curricula · International research collaborations

1 Introduction

The educational scenario in India has been subject to a series of transformative changes. The education sector is now opening its door to private universities—both national and international, competing to attract a large pool of young aspirants to their sprawling new campuses.

Today, the stellar role of leading Higher Education Institutions (HEI) of national importance in India (Government of India, 1961), such as the twenty-three Indian Institutes of Technology (IIT's) is globally recognized. Although funded by the Government of India (GoI), Ministry of Human Resource Development (MHRD), these institutions are given autonomy in developing and offering state of the art educational programs that match leading programs among international universities. The leadership role model that the IITs' offer form the flagship and benchmark for the curricula and educational syllabi that most other technical schools in the country adapt.

In this chapter, we give an overview of the Design educations programs among some of these leading HEI in India. We subsequently focus on the Design program at IIT Guwahati; the experience they gained in collaborating on an international project of developing courseware on Design for Sustainability (DfS); formally introducing DfS into their Design program; a few outcomes of field-based case studies undertaken to study DfS, and doctoral research initiatives on DfS now being pursued at the Department of Design.

Considering the present challenges faced by Indian society at this stage of its development, we make a case expressing the need for training a new generation of designers by formal inclusion of DfS into the Design curriculum of ongoing technical educational programs (Sharma, 2014). It is an opportune time considering the growing trend of Design educational institutions in the country. This training can significantly contribute to developing trained manpower engaged in the design and development of S-PSS and addressing actionable environmental concerns.

1.1 Professional Design and Design Education Programs in India

Commencing in the early 1970s, the IDC School of Design at IIT Bombay and the National Institute of Design (NID), Ahmedabad were the two earliest schools of Design in India offering formal Design educational programs in the conventional streams of Industrial Design and Visual Communication (National Institute of Design, 2013). By the late 1990s, both these schools commenced new programs in Design Management, Interaction Design, Experience Design and Transportation Design, among others. IIT Guwahati (Government of India, 1994) was the first among IITs' to commence its undergraduate Program in Design (1997), Doctoral program in Design (2002) and a Masters program in Design (2008). Except for IIT Bombay, the other IIT's and the Indian Institute of Science, Bangalore offers a Master's and Doctoral program/s in Design. In additions to these established institutions, there are more than 60 other private and public institutions offering programs on Design in various design specialization.

The growth of the Design profession, its relevance, contributions and importance for industrial growth has now gained recognition among Indian industry. A National Design Policy has been announced (Government of India, 2007). Following this announcement, the GoI, Department of Industrial Policy and Promotion (DIPP) has established the India Design Council (IDC, 2009). It promotes the professional practice of Design, design education and training. It has also instituted National Design Awards for good design.

1.2 Sustainable Development—The Indian Story

During international deliberations in the recent past, India has made significant contributions to aspects of new emerging concerns on global warming and the environmental crisis. It has contributed to bring the concerns of the developing countries to the attention of international organizations, and world leaders. It has committed and incorporated major changes to its environmental policy to achieve targets to set time periods. Towards meeting these ends, environmental and sustainability standards are being recalibrated and industrial practices being reworked by India Inc. that match international accepted quality benchmarks and norms (Government of India, 2011). Sustainable alternative energy means are being promoted and adopted in a major way. Professional and government agencies have instituted a number of awards in recognition and promotion of sustainable practices. Some of these are National Sustainability Awards instituted by the Indian Institute of Metal; ASEAN Corporate Sustainability Award; the Sustainability Awards institute by the CII-ITC Centre of Excellence, National Award for Success in CSR and Sustainability; and the Golden Peacock Award on Corporate Governance and Sustainability.

Despite these developmental incentives, there is still a lot to be achieved in the acceptance and practice of sustainable Design and Development by Indian industry in particular and society at large. Medium and Small Manufacturing Enterprises contribute significantly to the manufacturing sector. However aspects of sustainability in design and manufacturing seem inadequately addressed. This is primarily due to shortfall in awareness about sustainable practices in development of sustainable products, services and systems (S-PSS). It is also a pointer towards a lack of formal training on Design and Sustainability in the educational curricula across technical education programs in India. Considering the role model that the IIT's play, it is only appropriate that these institutions of national eminence lead the way in developing appropriate courseware and a model program focused on Design for Sustainability.

2 About Sustainable Developments and Environmental Education in India

The Brundtland report 'Our Common Future' states the definition of sustainable development as—"development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

The definition by its very nature is indicative of its all-pervasive coverage across multiple domains that impact economic, environmental and socio-ethical dimensions of sustainable development. Higher educational institutions (HEI's) have a critical and significant contribution to make by offering programs in Environmental studies. New generation of specialists trained in Environmental studies are required to contribute towards spreading awareness and promotion of environmental issues through multi-disciplinary approaches and research and development initiatives (Cortese, 2003:17; Tilbury, 2004). The Human environment and Agenda 21 (chapter 36, UNCED) (Stockholm Declaration, 1972) became the basis for framing the 'Education for Sustainable Development' (ESD)—a concept that involved objectives related to respect of human life and the development of critical thinking and responsibility towards environmental values and interdisciplinary relations. The UN declared 'Decade of Education for Sustainable Development (2005–2014) was an important step towards "the integration of the principles, values and practices of sustainable development into all aspects of education and learning". These initiatives played a crucial role in meeting challenges through "education, research and outreach" (Fadeeva and Mochizuki, 2010, pp. 250–254).

Introducing environmental educational programs across multiple- disciplines has been its outcome. Today, universities and research organization offer various programs in Environment Science, Environmental Engineering. Leading institutions/organizations in India, such as The Energy and Resources Institute (TERI); the

Centre for Science and Environment (CSE), New Delhi and the Centre for Environment Education (CEE), Ahmedabad have actively pioneered environment education and research programs. They have played a stellar role in influencing and contributing to environmental policy and their implementation. These institutions have also undertaken various publications and communication programs to promote and spread environmental awareness across various sections of Indian society. These include assessment of impact studies related to the environment coming out of these organizations. Most HEI of excellence such as the IIT's and Indian Institute of Science, Bangalore has established Centres for Environmental Research and have been contributing to education, training, research and policy in a very significant manner.

3 About the Design Program at IIT Guwahati

The Indian Institute of Technology Guwahati (IITG) is located in the capital city of Guwahati, in the northeastern state of Assam. The institute's Department of Design (DoD), where the authors are presently teaching, completed twenty years since the commencement of its three Design programs—four-year Undergraduate program; two year Master's program and Doctoral program in Design. Its Doctoral Research program is among the leading programs for Design Research in India.

Recognizing the rapidly changing landscape of a digital technology -driven era, DoD has been updating its Design programs by including state of the art domains that address the emerging needs, expectations and career aspiration of Gen X in the new millennium. It has realigned its integrated Design program following a project-based learning approach to prepare these trained professionals to the streams of specialization in—Product Design, Interaction Design, Graphic Design, Design Management. The program offers training that demand multi-skill sets to meet the various career and research opportunities required of industry and academia in Design for the Digital era. The fields covered include—Experience Design, Game Design, Interactive Systems Design, Design for Internet of Things, and Design for Sustainability and Social Innovation. These graduates find jobs as Product Designers; Graphic Designers and Web Designers; User Experience (UX) and User Interaction (UI) Designers among leading software, manufacturing and service sectors. The department has an excellent placement record.

3.1 Collaborative Partner on International Project—'Learning Network on Sustainability International' (LeNS in)

Design for Sustainability (DfS) has emerged as an essential area of study in the field of Design for the Environment. Training in this knowledge domain is now formally included in the curriculum at DoD, where students undertake design projects on DfS.

The department has immensely benefitted by participating as a partner institution from India on the European Union funded (ERASMUS +) project 'Learning Network on Sustainability—International' (LeNS.in). Prof. Carlo Vezzoli of Politecnico di Milano, Italy led this international project that involved collaboration between 32 international schools of Design among 16 universities from eight countries spread across Europe, Asia, Africa, South America and Central America. The project aimed to develop and share educational learning material on Sustainable Product-Service System (S.PSS) and Distributed Economies (DE). Participation on this international project gave DoD and our Indian partner-institute Srishti Institute of Art, Design and Technology, Bengaluru, an opportunity to develop learning resource material and case studies for jointly sharing the Indian experiences with participants from these leading international schools' of Design. All the learning material developed in the form of lectures, presentations, country specific-case studies from each of the participating institutions, is now made available for dissemination on the website (http://www.lens-international.org/).

3.2 Design Education on Systems Design for Sustainability

The DoD has benefitted immensely through this international collaborative partnership with the leading Design educational institutions in the world. Its research faculty regularly interact with a large pool of international researchers. The DoD is a member of the LeNS India consortium and collaborates with fifteen other local institutions in India.

The department offers an elective course on 'Systems Design for Sustainability' that is formally approved by the institute academic senate. This course covers the theoretical concepts on Sustainability; their broader implications; and application on projects. This course outline follows the 'Sustainable Product -Service System (S-PSS) model developed under LeNS project (Fig. 1) (Vezzoli, 2010; Vezzoli et al., 2017). Projects taken in the classroom are field-based and explore the scope and application of sustainable concepts that meet real-world needs drawn from the immediate environment. The course has been offered regularly for the last five years. The outcome of these efforts has resulted in research publications in reputed journals and conferences.

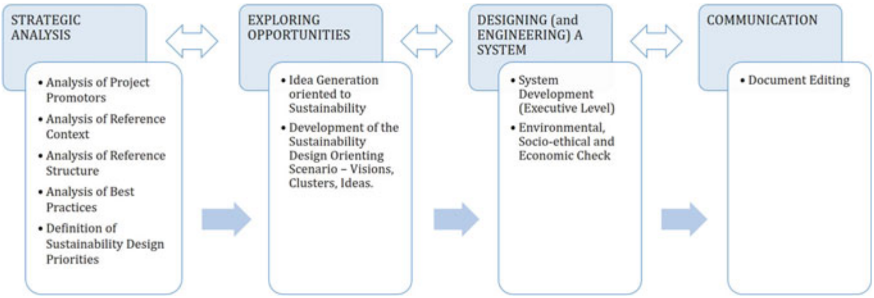

Fig. 1 MSDS—iterative stages of the modular method for system design for sustainability

3.3 Doctoral Research on Design for Sustainability at Department of Design

Systems Design for Sustainability forms one of the important thrust areas for researchers at DoD. With financial support received on the LeNS project, we were able to establish the LeNS Lab and the Sustainability and Social Innovation Studio at the department (Fig. 2). We have acquired computing facilities and related software for undertaking consulting projects on sustainability assessment to meet the needs of Indian industry. The lab facilities are open for researchers and scholars from all departments of the institute as well as associate institutes of the LeNS India consortium. A new generation of teaching faculty, doctoral researchers and students freely engage with other academic institutions across the country on projects related to Design for Sustainability. Presently five doctoral candidates are pursuing their PhD in the area of Design for Sustainability on topics such as Sustainability assessment standards of the built environment; Design research methods of PSS for the bottom of the pyramid; Development of agricultural machinery following S-PSS methodology; Study of catering services for the Indian Railways (Balakrishnan and Punekar, 2013) —following PSS approach to Sustainability.

Two Doctoral candidates have received their doctoral degree while the other three are ongoing.

3.4 Projects Undertaken at the Sustainability and Social Innovation Studio (SSI-S) and the LeNS Lab at Department of Design

We now present an overview of some of the thematic projects undertaken at the Sustainability and Social Innovation Studio and the LeNS lab at the department

– Study of Systems Design for Sustainability for Public Services

Fig. 2 LeNS Lab and SSI studio at department of design IIT Guwahati

– Design interventions on Sustainability and livelihood generation in the Handicraft Sector.

They are the outcome of field-based studies that follow the Sustainable Product-Service System (S-PSS) model involving systems thinking. They examine, analyze and make conceptual systemic proposals for live project domains relevant to our immediate society.

3.4.1 Study of Systems Design for Sustainability for Public Services

Case study 1 Design intervention proposals on S-PSS in a study of the Guwahati Railway Station.

Case study 2 Design for Sustainable—Product-Service System (S.PSS)—Study of Barduwa village in Assam to understand design interventions opportunities.

Case study 3 A study of the Akshaypatra Foundation in running the mid-day meal program for School Children.

These were undertaken as part of the educational course work on Systems Design for Sustainability highlighting the contributions of systemic proposals:

Case study 1 Design intervention proposals on S-PSS in a study of the Guwahati Railway Station (Hemani and Punekar, 2015).

The study on the Guwahati railway station complex was a studio design project with senior Design students undergoing the elective course on Systems Design for Sustainability. Focusing on systems thinking, the students undertook field studied at the premise of the Guwahati Railway station following the stages of the S-PSS model. It evaluated and analysed the various design elements of a complex public environment of the station premise focusing on spaces, activities and mobility. It made critical observations on approaches to decongestion, mobility of people and optimization of utilities and public conveniences in suggesting changes to the existing system and practices to optimize them. The final proposals showcase conceptual directions in the design proposal for a modern architectural space that taps its vast economic potential through socially and environmentally sustainable initiatives (Fig. 3). It accesses the anticipated challenges in its implementation and makes a case for an urgent need to include community-centric and locally pertinent sustainable proposals that are inclusive as also economically, socio-ethically and environmentally sustainable.

A paper presented on the outcome was presented during the STE conference 2010, received the best paper award and is available at (http://www.iadisportal.org/ste-2013-proceedings).

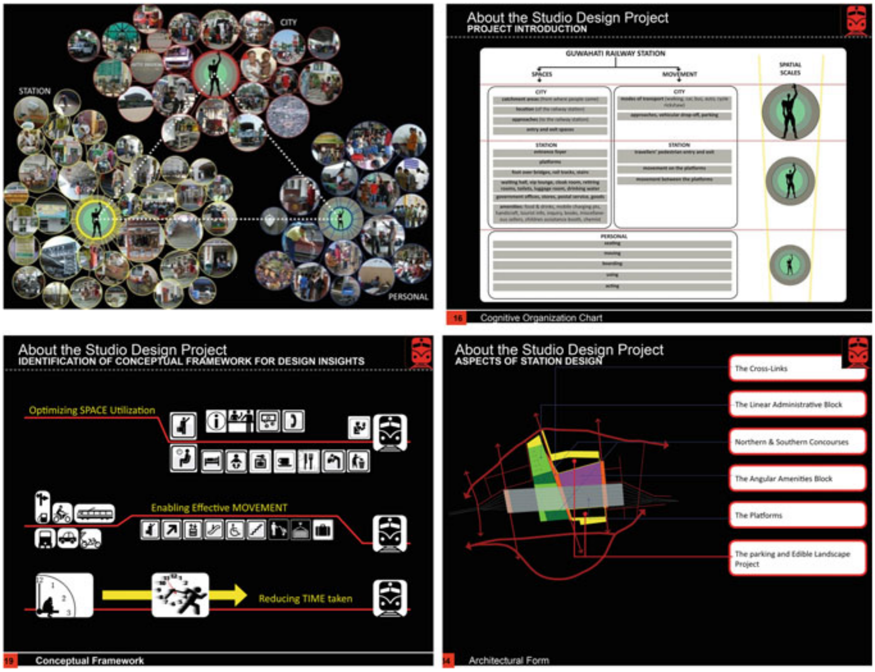

Fig. 3 Proposals for S-PSS intervention for Guwahati railway station

Case study 2 Design for Sustainable—Product-Service System (S.PSS)—A Study of Barduwa village in Assam to understand design interventions opportunities.

The second case example is again a field-based study in 'Design for Sustainability' undertaken with 22 undergraduate and graduate DoD students at Barduwa village in Assam. The village economy is agrarian with a compelling social–cultural mix of two religious communities living in mutually interdependent harmony. The farmers here cultivate paddy, mustard and vegetables during the agriculture season. Fisheries, handicrafts and handloom weaving form the other economic practice. Being the birthplace of saint-poet Shankardeb—one of the most revered social reformists of Assam, the village is an important socio-religious cultural centre that attracts local tourists during the year. The students undertook a systems approach following S-PSS methodology in studying the various activities and practices in the village from a socio-cultural, environmental and economic perspective. These activities included agricultural and fisheries; weaving and handicraft as a means of livelihood; education; tourism and local transportation system in the village. Drawing insights from field studies, they outlined a proposal based on sustainability, to conceive and reposition the village as state tourist destination celebrating the local saint-poet. The proposal re-envisioned the village economic activities through participation of the local community for the environmental and economic development of the village (Fig. 4).

These two case examples highlight the importance of introducing field-based studies in Design for sustainability (DfS) in the Indian context. We suggest that it should be made inclusive in the curriculum amongst all other institutions of higher learning in Design in India.

Case study 3 Akshaya Patra Foundation, Guwahati.

The Akshaya Patra Foundation is a Bengaluru based socio-cultural not-for-profit organization that is engaged in serving mid-day meals daily to nearly three million school-going children through their central kitchens situated across ten states of India.

The Akshaya Patra central kitchen at Guwahati city caters to serving nourishing meals daily to nearly 60000 school children attending government schools in rural areas in the vicinity of Guwahati city. A design workshop was organized for a group of visiting international students of the School of Architecture and Design, NTNU, Trondheim, Norway and the students of DoD undergoing the Design for Sustainability coursework. The objective of the workshop was to assess design intervention outcomes identified on-site following the S-PSS model on sustainability. The design proposals were conceptualized to optimize functional requirements of stackability; use of water, and efficiency in transportation. The concepts presented to the head of the Akshaya Patra Foundation received a positive response (Fig. 5).

Students in the process learnt to engage in the socio-ethical dimensions of sustainable solutions and the value and responsibility they share as a designer.

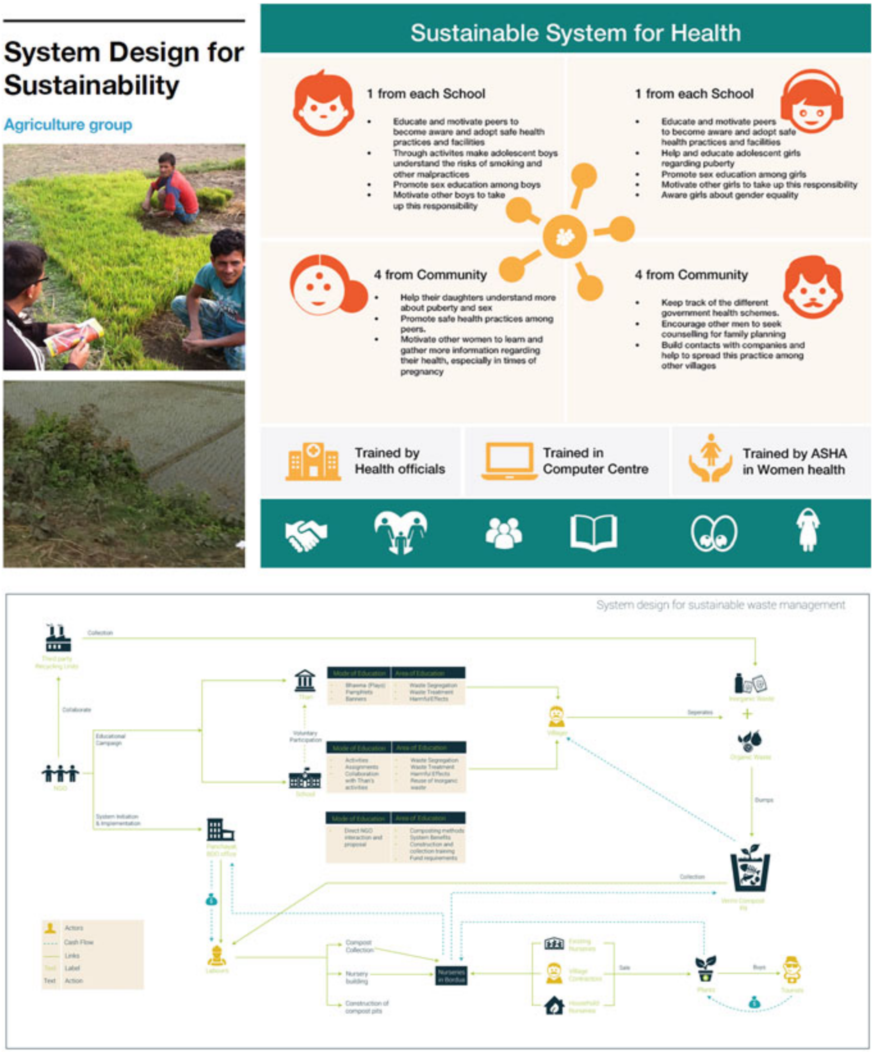

Fig. 4 System study of microenvironment of Barduwa village in Assam

3.4.2 Design Interventions in Handicraft Sector for Sustainability and Livelihood Generation

We present two projects in the handicraft sector on Sustainability, livelihood and bamboo handicrafts for rural communities.

Bamboo is a natural resource that significantly contributes to the economy of the northeastern region of India. The skilled crafts community produces a wide variety of handicraft products in the entire region. However, considering the poor infrastructure

Fig. 5 A study of sustainability at Akshaya Patra central kitchen, Guwahati

in rural and semi-urban locations, the potential use of bamboo craft to meet infrastructural needs of primary health centres and rural schools seem to be overlooked. We argue for the use of bamboo as an abundant natural resource in designing furniture that meet the needs of public institutions like Primary Health Centres and Primary Schools. They offer immense potential in the development of sustainable product-service systems that will result in the overall development of the local community. It proposes a sustainable and participatory design approach that focuses upon social innovation to achieve these goals. It offers livelihood generation opportunities for the bamboo artisanal community in the two states of Assam and Meghalaya.

In the first case example, the design team comprising of Prof. Sudhakar Nadkarni and Prof. Ravi Mokashi Punekar, developed a range of bamboo furniture for local rural schools and primary health centres (Fig. 6). The design proposals were economical to produce; environmentally appropriate and could generate local employment opportunities. The outcome helped to showcase how design could contribute to meet the basic needs of these public institutions for the benefit of the community.

The second case example is a project undertaken for the Directorate of Industries and Commerce, Government of Meghalaya. The project team comprised of Prof. Avinash Shende, Prof. Ravi Mokashi Punekar, Prof. Mandar Rane of the Department of Design, IIT Guwahati and the School of Industrial Design Centre, IIT Bombay. The project involved developing a strategic and holistic intervention on the theme Crafts, Community and Collectives (Rane et al. 2016). Following principles of DfS, the team developed a new range of bamboo lifestyle products drawing upon the specific skill sets and practices of the artisanal community in the seven districts of

Fig. 6 Development of bamboo furniture for rural schools and primary health centres

Meghalaya. The team designed a new range of novel utilitarian lifestyle products using locally available species of bamboo (Fig. 7). The products included handcrafted household products of high quality such as laundry baskets, lampshades, fruit trays, breadbasket, pendant lamps that had market potential for sales in contemporary urban markets. Three hundred craft persons underwent training in making these products. The artisans were introduced to techniques in weaving, dyeing, treatment of the bamboo, and in the use of moulds specifically developed for the new range of products. This enhanced the quality, consistency in size, and productivity. These products are now registered under the brand name *Shken.in*. This identity will ensure that the products are recognised and the craft persons get a good market response for their products.

The project is under a stage of implementation. The state government proposes to introduce support schemes that will extend microcredit and social security for the economic well being of these communities living on the margins.

Fig. 7 Design development of bamboo handicrafts for sustainable livelihood of artisans of Meghalaya

4 Discussions

The mandate of the DoD is human resource development through education and training. The overall contributions of these case studies and their impact on the ground are noteworthy. The next generation of trained designers working in the field of Design for sustainability are pursuing academic and research careers across leading institutions in the country. They have initiated courseware on DfS in their respective institutions. Other Graduate designers are working in some of the leading manufacturing industries.

The nature of the field-based projects introduced in the classroom are more often community centric. Here, decentralized modes of production is more often the norm. Participation of the stakeholders contribute actively in developing the conceptual directions leading to design intervention proposals. We anticipate that with the active participation of the community, this will have a positive social impact. The change will be seen over time for these kind of projects to show results. Such projects introduced in the classroom help to sensitise the young designers to the realities of the context of Design. They help to introduce the diversity of challenges and often contrasting demands of opportunities for design intervention among the formal and informal sectors of Indian society.

5 Limitations of Interventions and Future Scope

The geographical location of the institute at Guwahati offers a few limitations, as the northeastern states are relatively less industrialised that other regions of the country. The case studies presented here are, therefore community -centric and livelihood based. For a strong impact of DfS we must address the needs of the manufacturing and agriculture sector. The DoD is presently working on developing a series of Executive development programs on DfS targeted to senior managers and captains of industry. These programs have to meet the diverse challenges of addressing the immediate concerns of the large industry and the Medium and Small Manufacturing Enterprises sector (MSME). The DoD is aware that formally introducing DfS in the Design curriculum is a significant and critical consideration to broaden the scope of Design activities. It will be critical to ensure that research and practice in Design for Sustainability develop concurrently.

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Green IT Strategies: Information Management in Architectural Regenerative Design

Anna Brudnicka and Adam Rybka

Abstract Considering the definition of Green IT as a combination of environment and information technology, this paper tries to introduce the concept of green IT as a definition of information management in regenerative design in building sector. The article discusses an innovative approach to the housing estate for the city. The goal of the Activities is to limit the negative impact on the built environment and city residents. The article discusses selected issues and defines the framework for future regional programming. The review structure was determined based on the off-grid framework. The result shows that sustainable development strategy projects can be implemented using selected elements of the data cloud. This will allow future strategy building in cities based on selected technology categories. This will enable consistent actions to be taken in the area of innovative projects. The concept is to develop districts capable of working outside the network. Resources will be used in a closed loop. Technology will be used to monitor behavioral patterns. The data will be sent to a cloud established for a similar settlement. This will allow you to learn from each other. An integrated information management system will enable Existing Technologies.

Keywords Sustainability · Architectural regenerative design · Green IT · Building management · Energy self-sufficiency

1 Introduction

The built environment has a significant influence on sustainability. Buildings and the way in which we design, construct and management them have been a huge contributor to climate breakdown. Despite a lot of initiatives fighting with climate

A. Brudnicka (✉) · A. Rybka
Faculty of Civil and Environmental Engineering and Architecture, Rzeszow University of Technology, Rzeszów, Poland
e-mail: a.brudnicka@prz.edu.pl

A. Rybka
e-mail: akbyr@prz.edu.pl

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change we have taken passive "stop getting worse" as the last possible action. On the positive side we can "start to regenerate". We have strategies, tools and approaches that will allow to do next step in thinking about sustainability. Regenerative and restorative approaches can transform this enabling build environment to became part of climate regenerative solutions.

2 Background—Redefining Sustainability

The growing population causes a need for growth that enforces environmentally sustainable policies. The idea of a circular economy is transformed by moving to a regenerative economy. That allows socio-economic and ecological systems to constantly evolve. John Fullerton defined regenerative economy by the following assumption: "*Economic vigor is a product of human and society vitality, rooted in ecological health and the inclusive development capabilities and potential*". (Fullerton, 2015).

The regenerative economy is built by sustaining human, society and economy vitality. It is also developing variety, integrity, responsiveness of every level of global civilization. The task facing of creation of today's principles of civilization is to shift into alignment with the regenerative rules described by Fig. 1, showing that regeneration goes far beyond sustainability.

The current system of conventional economic design where we produce, consume and leave waste, is putting us at risk of sudden climate change and social and ecological breakdown. The improvement of traditional design is the introduction of eco-efficient solutions. The final result still has a negative impact on the environment. Regenerative design is one part of sustainable development. This is not the same as sustainable design. Sustainable development is a process that continues without degradation. Such development does not regenerate by itself. Sustainable design must meet the basic needs of man without degradation of the environment. The regeneration project goes further. Regenerative systems restore, regenerate and recover. They create sustainable development that regenerate the natural capital and services (Reed, 2006).

Converting design methods from conventional to green, through sustainable and regenerative, will reduce energy demand. Regenerative methods of developing the built environment can become a way to generate resources and energy. They will also allow the removal of accumulated pollution. They will enable you to transform waste into useful resources. Understanding local traditions and knowledge is another important benefit. This affects the preservation or creation of the cultural identity of local communities. (Pedersen Zari, 2010).

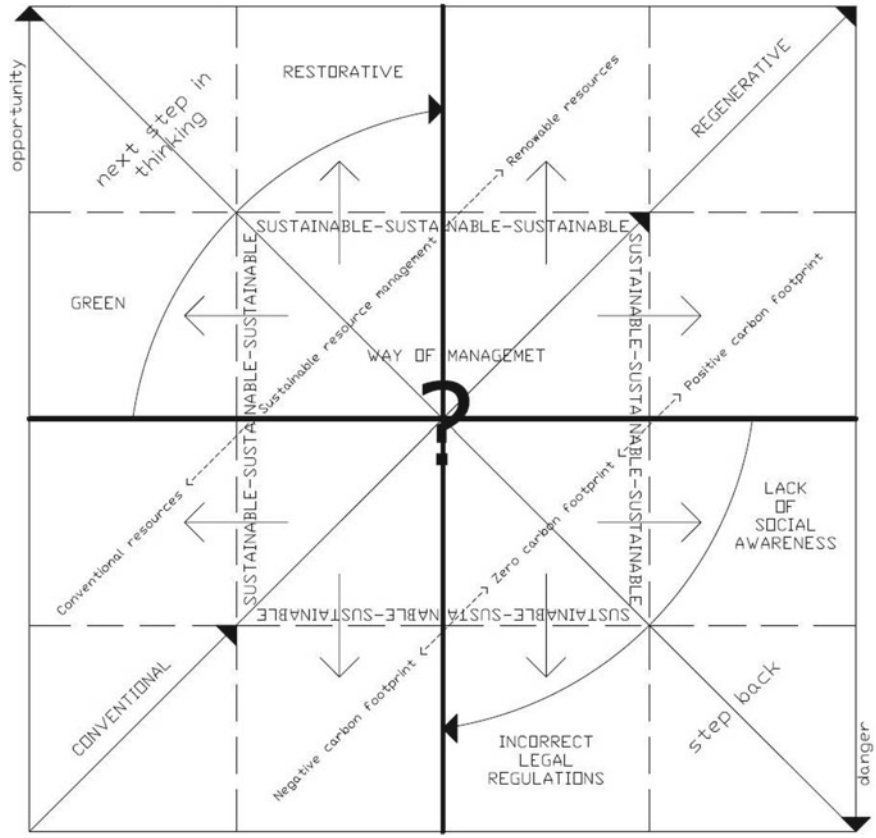

Fig. 1 Stages of development changes (archive of Anna Brudnicka)

3 Green IT—New Meaning in Building Sector

Green information system (green IS) or Green IT as per International Federation of Global & Green ICT "IFGICT" is a combination of a built environment and information technology. There is a complex relationship between information technology and the built environment. The reason is the impact of production, use and disposal of information technology negative on the built environment. A greener approach is called green information technology. It considers the impact of IT on a built environment primarily as a problem that should be alleviated. Another effect includes the positive impact of using information systems (IS) to improve the ecological sustainability of enterprises and communities; this is called green IS. This green point of view sees IS as a partial solution to many environmental problems. Green IS is a search for methods to solve the negative impact of information technology on the built environment. Green IS facilitating the reuse of waste and can serve as a tool for industrial cooperation that includes' the interaction of different industries for the beneficial reuse of waste flows or forms of energy. This promotes a more economical production system and less negative impacts on the built environment. (Ghalomi, 2013). Green Information Technology (Green IT) refers to the application of ecological sustainability criteria, such as: pollution prevention, product management, the use of clean technologies to create, acquire, use and remove IT technical infrastructure. Green IT is also used within management practices that relate to environmental sustainability in organizations (Mithas, 2010).

Green IT means many things to many specialists, but most definitions come down to key aspect: sustainability. Sustainability is about ensuring that we take out no more that we put into a closed system. **The challenge is how we measure inputs and outputs. IT as a data repository and reporting tool is the main instrument for building management**.

Buildings are usually not a part of IT directly, but are still a significant contributor of carbon footprint. While most contemporary focus of Green IT has been on the operational aspect of the facilities, the architecture and design of housing, industrial facilities and many others types of building sector have a strategic role to play in our carbon footprint (Unhelkar, 2011). Therefore, Green IT is the study, design, manufacture and implementation of any technological device, information or communication system carried out in an efficient and effective manner with minimal environmental impact. The carbon from buildings depends on materials, location and facilities like air conditioning, lighting or ventilation. The need to consider the carbon issues during construction of buildings and facilities and subsequently focusing on its optimized operation and maintenance is crucial to the holistic approach to a regenerative development. The architecture and design are the combination of strategies relating to the type of used insulation, facilities to obtain and recycle water, solar charging and many others are all examples of strategic aspects of environmental asset management. Building equipped in this infrastructure fall under category of green facilities management and shows regenerative properties. Considering above definitions and the role that information technology plays in building management, we'll try to introduce the concept of green IT as a definition of information management in regenerative design on an example of regional specialties.

4 Programming the Regional Specialties

Regional specialties have become the main methodological category. The emergence of regional specialties in the economy is a complex, multi-stage process. It is a process that reflects the essence of development. The new urban model result in the emergence of Various elements of the region's internal potential in interaction with regional stakeholders and regional management initiatives.

Regional development is the process of creating ideas and developing them for the needs of projects. Figure 2 shows the path to generate creative regional specialization. The rank and strength of stakeholders at the regional level allows the creation

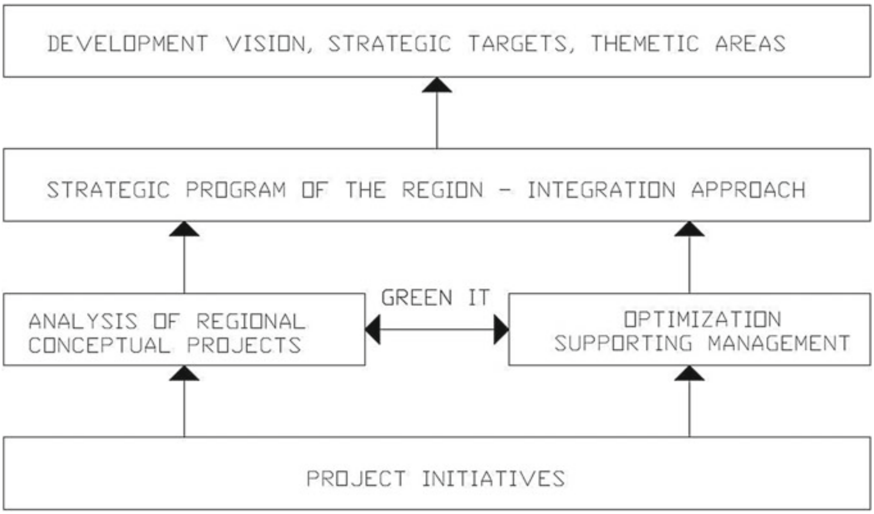

Fig. 2 Green IT as a data repository and reporting tool in generation of the creative specialty of the region (archive of Anna Brudnicka)

of various types of project initiatives. They generate the basis for creating conceptual designs. In this way, an offer is created, enabling selection of regional project packages due to their potential impact at national and international level (Klasik, 2018).

5 Project Initiatives—Off-Grid Complex

Research on the transformation of the spatial and economic structure of cities is increasingly pointing to emerging new development factors. We find there advanced technologies that save human capital, social capital as well as time and energy. These technologies are very important in urban development. A modern city is not only its physical structure, but also a huge network of cybernetic connections, seeking to optimize the use of city resources and processes. The main goal is to prevent negative externalities resulting from the functioning of the city. Conduct in accordance with the principle of sustainable development is sought. The main goal is to develop a settlement in which the resources will be used in a closed loop. From the stages of planning, designing and creating and constructing buildings, through their operation, maintenance and conservation, to the final demolition and recycling of residues. The aim of the project was to check whether apartments in small groups with a central unit are able to create a target community developing towards sustainable social, economic and environmental development. Development focused on the principles of regenerative design. The proposed complex is to show the advantages of natural construction. The concept combines various innovative technologies. These are homes with positive energy consumption using renewable energy. Methods for energy storage, water and waste management, as well as food production were sought.

The main food source is fruit and vegetables grown in seasonal gardens. The menu is supplemented with food obtained from slaughtering livestock. Waste management assumes the highest possible degree of segregation to maximize their reuse. The largest percentage of waste is used as animal feed and compost for field utilization. Biogas plants use non-compostable waste, which represents only a small percentage.

Rainwater is retained and stored in storage tanks. Households receive useable water. Water with inferior properties is used to irrigate fields. The basic interactions of the system shown in Fig. 3. Figures 4, 5 and 6 present a proposal of the spatial arrangement of components of the system.

Electricity is obtained from photovoltaic cells installed on roofs and from biogas production. An important element of the system is the smart grid which controls

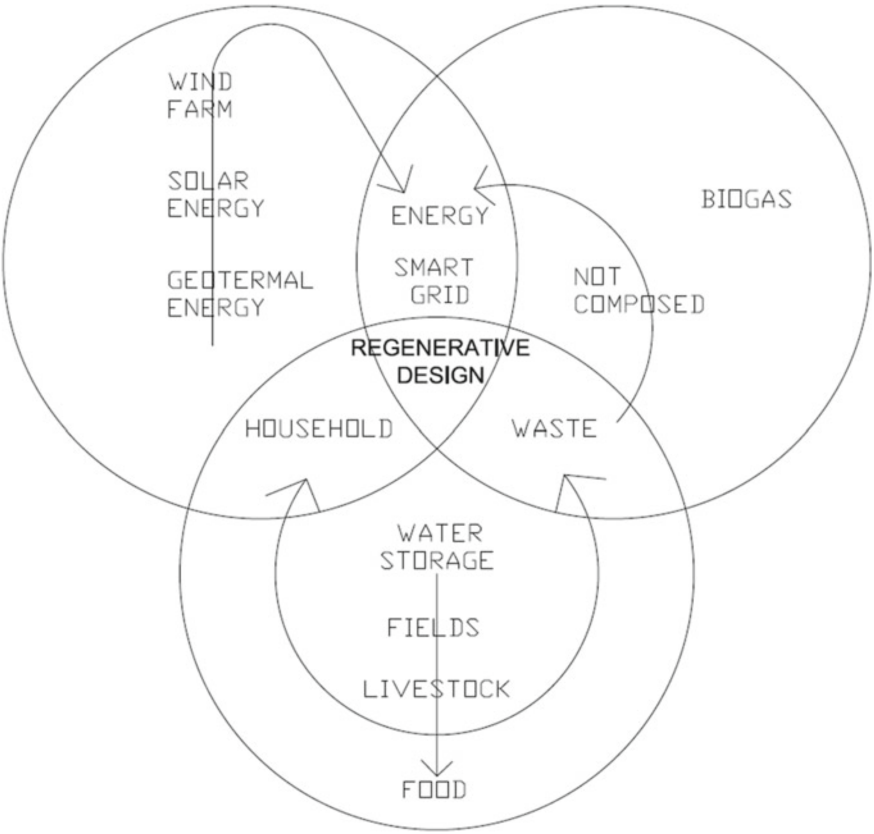

Fig. 3 Off-grid complex as an example of regenerative system (archive of Anna Brudnicka)

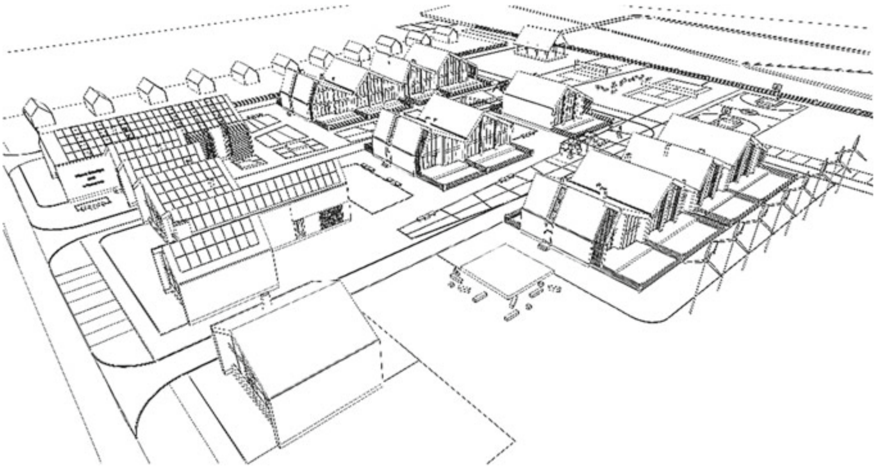

Fig. 4 Regenerative off-grid complex—design concept sketch (archive of Anna Brudnicka)

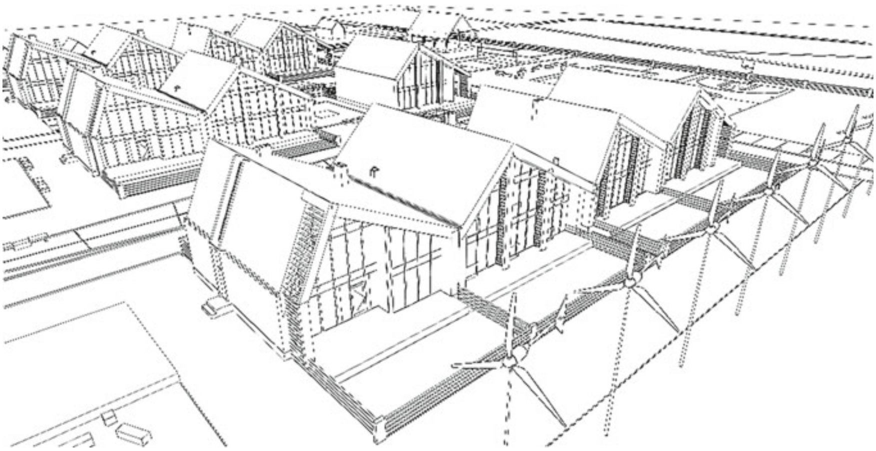

Fig. 5 Regenerative off-grid complex—design concept sketch (archive of Anna Brudnicka)

energy demand, its surpluses and shortages. The system distributes energy to the electric car spots and settlements.

The key role is also played by the type of materials from which houses are constructed. The concept assumes the use of the straw bale system. In this method the main building material is straw, which performs structural and insulating functions. The system has a number of advantages. Among the main ones can be mentioned high insulation value, easy availability, naturally fire—retardant, low cost.

Straw—bale technology is characterized by zero carbon footprint, possibility of composting, $\lambda = 0.052–0.080$ W/mK [6]. The use of straw bale technology significantly reduces the cost of building houses. The functional and aesthetic expectations

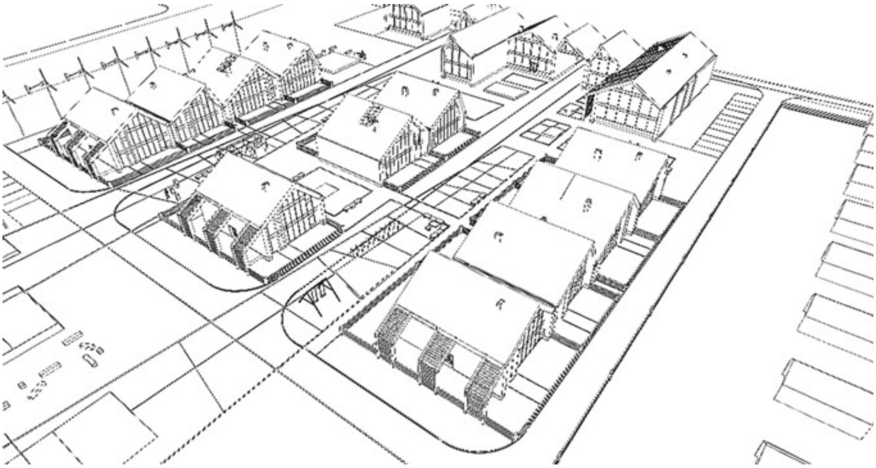

Fig. 6 Regenerative off-grid complex—design concept sketch (archive of Anna Brudnicka)

Table 1 Rating complex features to environmental factors

Building features	Environmental relevance	Comments and actions
Location	Regional specialties profile adapted to specify of the region;	Study directions and changes of regional land use, migrations of society; reduction of energy transmission losses
Architecture and design	To maximize the use of available natural resources for the building	Windows facing sunlight; cross-ventilation
Construction/materials	Zero carbon footprint	Replaces conventional materials with environment friendly materials e.g. straw bale construction
Associated infrastructure	Regeneration	Small self-sufficient dispersed units based on renovable energy sources

of modern society are maintained as in the case of other technologies (Rybka, 2018). Table 1 presents chosen rating off-grid complex features to environmental factors.

6 Green IT as Analysis and Optimization Tool for Defining Strategic Program

Coordination is the most important feature of any effective system. Allows distributed elements to work together to solve a problem. The systems reliability is based on research on measurement methods and predictability. Coordination also aims to better understand infrastructure interdependence. Effective energy management is based on its proper management.

The most important targets of system are:

– energy security,
– safety,
– minimum environmental footprint,
– robustness (resilience and reliability),
– finance ability,
– flexibility (optionality and extensibility).

Table 2 illustrates set of components useful to compare, and to formulate and to solve various optimization problems, based on objectives and constrains. Presented basic mappings are an introduction to the analysis and optimization of the research problem. Selected combinations show interrelationships of related system elements (Brudnicka, 2019).

Throughout the tracing process, we will have to continuously analyze the elements that are part of the synchronized units to know if its use, activation, treatment is the necessary for the greater efficiency of the system. Figure 7 is an example of wind farm management (at the level of a small housing complex) and the smart routes for better optimization of system.

Table 2 Tracing synchronized units impact on energy security

Components and structures	Properties	System qualities (targets)
– Synchronized energy demand and supply sensing – Real-time monitoring – Early warning system – Energy obtain and storage – Integrated planning of development – Synchronized units – Advanced optimizing controls – Grid integration – Data management – Micro grids – Coordination (central and dispersed) – Regulatory – Financial resources – Type of consumers – Technology of buildings (e.g. straw-bale) – Climatic conditions – Modern methods of processing raw materials	– Controllability – Observability – Tolerance of load – Scalability – Local optimization – Data/system/device interpretation – Fault tolerance – Efficiency of energy and network resources – Emissivity – Ability to regenerate – Possibility of expansion	– Closed system economy – Minimum environmental footprint – Affordability – Energy security – Safety – Robustness – Flexibility – Finance ability

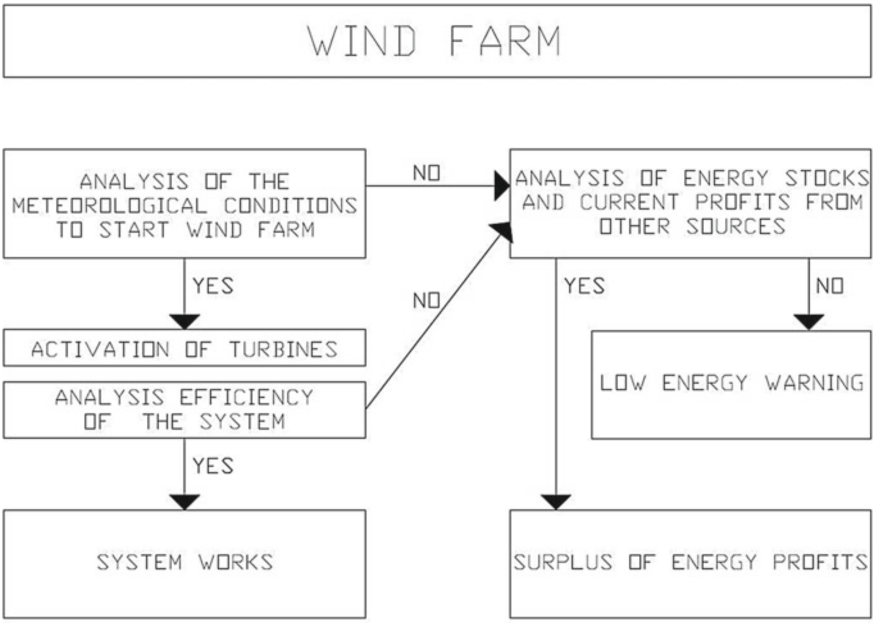

Fig. 7 Process diagram of wind farm system management

The success of energy independence depends on the diversity of energy sources. It is necessary to equip units in devices to obtain energy in various conditions.

7 Results and Discussion

In the face of galloping change, local governments need to look at their actions from a completely different perspective. Article tries to answer the question concerning how a small eco-community based on the principles of regenerative design might impact on the energy security. The main purpose was to contribute to getting a better and fuller understanding of architecture in the context of its impact on the environmental sustainability, prices, and access to a broad audience. The study is an attempt to show the general trend of the possible development and popularization of ecological architecture in the city.

The research tool produces number of system of interactions that is to maximize energy self-sufficiency. This principle highlights on the need to recognize and minimize the economic and environmental effects of use conventional energy. The optimized system layout is shown in Fig. 3. Individual components should be subject to reporting tools, which are initially presented in this chapter.

In Poland, regenerative design is still an experimental construction. The barrier is the lack of legal regulations concerning construction technologies using straw cubes and social awareness questioning the principles of construction and operation of the described facilities. Changes in legal conditions would undoubtedly contribute to the spread of this branch of construction and would increase the degree of recognition of this phenomenon.

8 Conclusions

The article presents the practices of intelligent initiatives in planning settlement units. Correlation of factors influencing the functioning of settlements allows to understand the role of economic, environmental and social variables in regenerative design.

Results reveal that the evolution strategic program of the region highly depends on its local context factors. An attempt to achieve a balance between the continuity of urbanization processes and the environment is to implement green IT in the new meaning as a main instrument in building management. This work presents findings from an investigation into directions of development of single-family housing, focused on energy self-sufficiency. The findings highlight the significance of information management in off-grid units. Regenerative system requires different strategies for actions control. Following are the list of green cloud strategy considerations that need to be expanded in detail in practice:

– online, real-time list of energy stocks inventory that enables of location and uses of the surpluses and deficits,
– efficient decommissioning in case of exceeding "acceptable risk",
– capacity forecasting—settlement capacities need to be estimated on a continuous basis as the demographic changes. the correlation between growth, and corresponding r capacity, is ascertained based on statistical analysis, trend spotting, and estimating the impact of technological innovativeness,
– lack of visibility of emissivity of carbon and particularly its mapping—no prevention options.

Energy self-sufficiency should be the basis for the development of modern cities. It should also be a priority in research related to settlement planning. This work presents guidelines for defining and directing a smart city strategy and planning activities towards the most appropriate fields of implementation.

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Sustainability, Green IT Awareness and Online Shopping: An Australian Perspective

Amelia (Minh Hue Chi) Nguyen

Abstract The Internet has significantly influenced society in many ways, shapes and forms. There is no doubt that one of the most important inventions of the 20th century is the Internet and the World Wide Web. Humans have advanced far more rapidly than their ancestors at an exponential rate and generated numerous new information and opportunities than their predecessors. Online shopping can be perceived as a product of this technological change and a crucial component of the Industry Revolution 4.0. However, due to the difference in social contexts and social fabrics, people from different countries are not necessarily behaving the same way when it comes to spending their hard-earned money via a hyperconnected network. This research is particularly concerned with how Australian people perceive online shopping in terms of their behaviours, and provides business operators, decision makers, marketers, consumers and policy-makers with important insights. Given the ever-increasing global concerns about sustainable development and the conservation of natural resources, this paper also attempts to determine whether online shopping might contribute to sustainability either positively or negatively. The chosen research approach involves mixed methods which has a heavy focus on quantitative data collection via web-based and paper-based survey and a component of qualitative research. The findings suggest many Australian shoppers believe that online shopping, if operated properly, might contribute to reducing the carbon footprint as well as air pollution and global warming. It is acknowledged that the survey research design might cause this research to be subject to cognitive bias while the sample frame narrows the representation to largely Western Australia so future research is encouraged to review it from this standpoint. A set of recommendations is also developed based on the findings and the characteristics of different groups of special interest.

Keywords Sustainability · Green IT · Online shopping · Australia · E-Commerce

A. (Minh Hue Chi) Nguyen (✉)
Curtin University—School of Management, Perth, WA, Australia
e-mail: amelia.nguyen@curtin.edu.au

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1 Introduction

It is not presumptuous to say that the Internet is an invention which has greatly disrupted the lives of humans. Means of communication and business trading have been impacted the most in a uber-connected society. Technology-advanced countries began to see more opportunities and problems associated with these more innovative ways of doing business. The way that eCommerce is fundamentally shifting the way that Australians make purchases, and their expectations of these transactions, might be one of them. Figure 1 provides a breakdown of how this sector is currently performing in terms of revenue, profits, growth rate, number of businesses, employment opportunities and market share nationwide.

Overall, the online shopping sector in Australia is performing very well with a revenue of AUD$ 23.7 billion in 2018 generating approximately $759.2 million of profit and an annual growth of 14.3% over the last 5 years (Miller, 2019).

a. **Online Shopping?**

Due to the exponential expansion of Internet marketing, consumers are now exposed more than ever before to wants and needs created by digital marketers. The wave of online shopping has constantly emerged as a top priority of giant retailers in terms of not only how to attract more consumers to their e-commerce sites, but also how to improve the overall multi-channel retailing experience.

In 2018, Australia contributed a total of A$28.6 billion to global e-commerce consumption. The annual report issued by Australia Post suggested that eight out of ten Australian shop online on a regular basis. The largest contributor to these numbers is the mounting amount of time the population are now spending on electronic devices such as laptops, tablets, and mobiles, which lures them away from brick-and-mortar

Fig. 1 Online shopping behaviors in Australia—prepared by the author

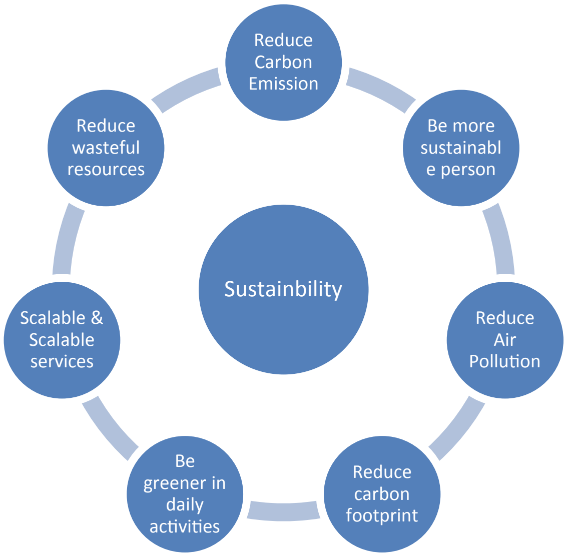

Fig. 2 Sustainability factors affecting online shopping behaviour in Australia—prepared by the author

shopping. On a monthly basis, the average Australian spends around 70 h a month online engaged in a wide variety of activities. Figure 2 have painted a big picture about sustainability factors impacting online shopping behaviours in Australia.

b. **What is Sustainability?**

Sustainability as a policy matter was first introduced in a report by the United Nation, which is the Report of the World Commission on environment and development: "Our common future" (Brundtland, 1987). The main concern of this document was the intensifying dilemma between mankind's desire for better living standards and the scarcity of natural resources available for sustainable exploitation. There are three underlying pillars to this concept: environment, society and economy. Some might argue that this view places a heavy emphasis on economic improvement and considers environmental issues in the aftermath. The concept of sustainability emerged from the concern that the gratification of the needs and wants of the current generation is achieved at the cost of irreplaceable natural resources, which may compromise the well-being of future generations. However, despite exploiting numerous natural resources, the current generation also has contributed to the future generations with a massive volume of capital, knowledge included (Kuhlman and Farrington, 2010). It is now a matter of irreplaceability, in other words, what must be compromised more than others and whether such compromise is worthwhile. Nonetheless, there is an urgent need to a arrive at a balanced perspective that one view can complement another rather than being in opposition.

2 Sustainability Factors Affecting Online Shopping in Australia

Just like any other business model in the 21st century, online shopping is also subject to sustainability. In order to be well received by consumers, online businesses including large corporations need to be perceived as having sustainable business models. This section will explain sustainability and show how this factor plays a role in the online shopping business model and whether or not should business operators view it as an advantage or challenge.

c. **Issues with Urban Logistics**

Urban logistics issues have received significant attention for the last few years due to increasing global environmental concerns. This is because logistic activities associated with accelerating volumes of online shopping have created a surge in this industry. E-commerce is perceived as a modern distribution channel of the 21st century thanks to the globalisation of by-products of urbanization (Schöder et al., 2016). As a result, densely populated areas often experience congested commercial traffic alongside pollution, including air and noise pollution (Bertram and Chi, 2018). Many logistics solutions firms have started to introduce more sustainable initiatives from both manufacturing (i.e. reduce wasteful consumption of resources) and shipping perspectives (i.e. carbon emission, air pollution and global warming). Industry has called for and is willing to invest in R&D for biodegradable materials together with greener shipping methods by, for example, requesting that consumers demand less express shipping (Muerza et al., 2018). New electric-powered vehicles are also being promoted as a means of transportation. Nonetheless, this technology is still in its infancy and is still costly, so not many SMEs are willing to adopt it just yet.

d. **Potential Reductions in CO2 from Passenger Transport from Online Shopping Practices**

Online shopping might have some potential in reducing CO2 produced by consumers as a result of more sustainable habits. It is argued that people who shop online more often for everyday items like groceries or office supplies tend to produce less carbon than those who drive to the store to buy these items. In Sweden, a study based on the calculation of a predicted increase in online shopping frequency coupled with anticipated population growth would lead to a 22% decrease in carbon emission by 2030 in comparison with 2012. Impressively, this calculation also takes into account the click-and-collect approach. In the absence of population growth, which might be applicable to Australia given the aging population, this reduction could increase to 31% (Rosqvist and Hiselius, 2016). Via strategic placement of high traffic stores location (e.g. pet shops, consumers electronics and the like) and optimal shopping mall locations, carbon emission can be reduced tremendously (Carling et al., 2013, Jia et al., 2013).

Overall, online shopping is expected to prompt consumers to feel that they are being more sustainable through the provision of scalable or economy-of-scale services, and encourages them to think greener in their daily activities. By engaging in greener activities, people can contribute to environmental protection by decreasing their carbon footprint, global warming and air pollution and many other taking many other positive course of actions (Fig. 2). From an industry perspective, business might be able to conserve resources and water if they re-structure and streamline their supply chain to accommodate the e-commerce boom.

3 Research Method and Research Questions

It is important to note that the most effective research does not often rely on a single approach or method; rather, a combination of complementary multiple methods is adopted (Saunders, 2016). Research approaches tend to be in the centre of the continuum or leaning towards qualitative or quantitative, but rarely are they strictly one or the other. In this study, most of the collected primary data is quantitative, although one qualitative component is also incorporated. In terms of secondary data, a purely qualitative literature review has been conducted to enhance the effectiveness and accuracy of the primary methods.

The ensuing section will outline in detail the approach that the researcher adopted to develop the research construct and sampling procedure, and to ensure the validity and reliability of the study.

a. **Survey Design**

Owing to the deductive nature of this study, the questionnaire is the research design of choice. The survey begins by eliciting demographic information such as age, gender and educational background to categorise participants into different groups based on their personal characteristics. Afterward, participants are asked to indicate their Internet usage and online shopping frequency and products of choice. The main content of the survey is intended to measure respondents' attitudes towards (1) psychological, (2) functionality, (3) content, (4) security and delivery and (5) sustainability factors and whether or not these factors encourage or discourage them from engaging in online shopping.

b. **Scale of Measurement**

This study is designed using itemized-rating scales, which requires the respondent to select from a number of response categories that typically reflect increasing amounts of the attribute (e.g., attitudes, satisfaction) being measured.

It adopts the Likert scale, which is a "self-report technique for attitude measurement in which respondents indicate their degree of agreement or disagreement with each of a number of statements" (Lamb, 2014). In this case, the researchers want to measure respondents' attitudes towards online shopping by developing a 1–5 interval scale where 1 = strongly disagree and 5 = strongly agree. Brown and Suter (2013) suggested that a Likert scale with an odd number is essential for a questionnaire survey. In this way, people have the option of expressing a neutral opinion should they feel that they do not have enough experience to express a strong enough opinion.

At the end, respondents are also invited to provide further comments with regards to any of the factors of concern such as psychological, functionality, security, content and sustainability factors as a form of qualitative data.

c. **Target Population and Target Sample**

For a survey strategy to be effective, the sample needs to be representative of the population. The target population of this study comprises individuals aged between 18 and 62, or millennial and baby boomers who are studying and working in Australia. Pew's Research Centre suggested that millennials are individuals born between 1981 and 1996 and anyone born post-1996 will be categorised as generation Z (Fox et al., 2001). The milennials are entering their prime working age or mid-career, they have started to form their own purchase intentions and opinions, which are often very sophisticated, brand-oriented and social-status-driven (Butcher et al., 2017), while being early-adopters of the newest trends in their area of interest.

Given that the target population for this study are residents of Australia, the main sampling frame is largely based on tertiary students who used to be or are currently enrolled in courses, and other people who work at Curtin University. This includes alumni, re-enrolled and new students. Considering a community of more than 2000 individuals actively studying and working on average, this sample frame constitutes a diverse range of cultural, socioeconomic, and educational backgrounds. A sample size of 100 and above of this community will ensure a confidence level of 95% or a 5% error margin (Saunders, 2016). Given the population size, it is practically impossible to engage every single element in the study. A statistical inference will be drawn from the sample.

d. **Data Collection**

The survey questionnaire is developed and distributed via the online platform, Qualtrics. In order to ensure a higher response rate, paper-based surveys were distributed and then transferred to Qualtrics. The quantitative and qualitative components of the study are presented concurrently as and when the respondents are going through the questionnaire. A simple random sampling procedure is taken to distribute the survey, which consists of Likert-type statements, multiple choices and open-ended questions. The target audience can respond to the survey via several online platforms such as LinkedIn, WhatsApp, Facebook or in person as and when they receive the paper-based survey.

e. **Data Analysis**

In order to analyse the collected data, SPSS is used to conduct Cronbach's Alpha and factor analysis. The version of SPSS of choice is version 24. Cronbach's Alpha analysis is adopted to ensure the reliability by assessing the internal consistency within a group and determining which factors have a stronger loading (Pett et al., 2003). Since the survey design relies heavily on Likert-type scales, the application of Cronbach's Alpha coefficient is mandatory to assure internal consistency reliability (Gliem and Gliem, 2003).

In addition, factor analysis is undertaken for the purpose of data extraction or narrowing a vast number of items into factors. This analysis is widely popular in psychological and educational areas and it is especially effective in dealing with self-reporting mechanisms (Hogarty et al., 2005). Factor analysis is a multivariate statistical process used for data extraction, theory formation and ensuring construct validity (Williams et al., 2010). Afterward, results will be depicted using pie charts, bar graphs and heat maps where necessary to communicate findings.

f. **Reliability and Validity**

The level of reliability indicates whether there is a strong possibility that other researchers will be able to draw similar results should they decide to replicate the outlined research methodology. The level of validity of a research relies on how the researchers adhere to the research method's requirements over the entire course of their research. Both of these factors play an important role in producing a high-quality research. Data quality will be tested by means of appropriate survey tools which should be valid and/or reliable. In saying that, both validity and reliability need not be present in order to deliver a successful research as long as one is done correctly.

Given that the focus of this study is to examine factors that influence Australian online shopping behaviours, the primary research question has been formulated to identify sustainability issues associated with online shopping in Australia.

- What are the advantages or disadvantages of online shopping with regards to improving sustainability awareness?

Objective: *To identify the advantages or disadvantages of online shopping in terms of improving sustainability awareness*.

4 Results

The collected data indicated a number of trends and patterns in terms of the demographic backgrounds of respondents. Characteristics including gender, age group, frequency of Internet use, online shopping frequency and many more will be covered to obtain a comprehensive understanding of the participants collectively.

e. **Gender proportion**

The first preliminary question asked respondents to state their gender. The majority of participants are female, with 76 respondents accounting for 70% of the samples

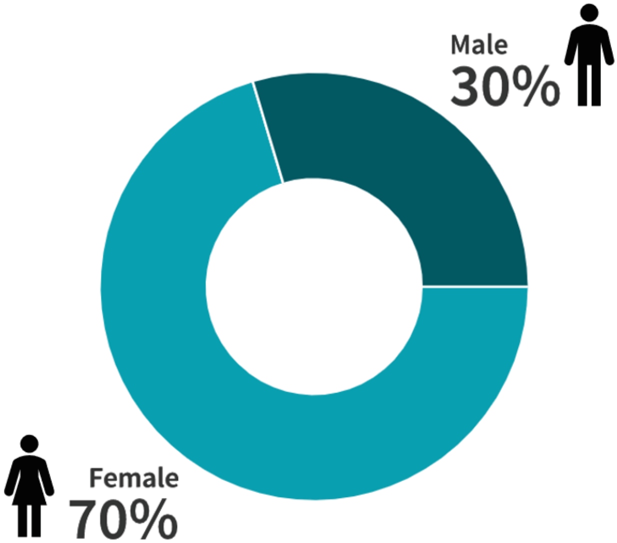

Fig. 3 Gender proportion of survey respondents

(Fig. 3). Given that the sample population comes from both administration and health-science fields, it is often seen that females outnumber males in these areas. Moreover, the Auspost Report of 2019 also suggested that women Internet users are often more likely to participate in online surveys than do their male counterparts.

f. **Age proportion**

Moving onto age range, the researcher was also interested in discovering how different age groups behave differently in an online environment. As discussed earlier, since Australian millennials are contributing to the growth of the online shopping industry, it is not surprising to see them making up to 47% of the sample population (Fig. 4). Additionally, it is acknowledged that the number of baby boomers participated in this study is almost little to none.

g. **Educational and Professional Background**

With regards to the highest level of education reached, the majority of participants (45%) have a Bachelor degree, followed by 25% with a Master degree (Fig. 5). It is noted that no respondent held a Doctoral degree.

Additionally, the most popular major was Health Sciences (15%) followed by Marketing (13%) and Management (12%) (Fig. 6).

In terms of occupation, participants come from a wide variety of jobs and employment positions. The majority of respondents are Administrators either in a business or health practice setting (Fig. 7). Another major cohort are tertiary students or people who are studying at a tertiary education institution.

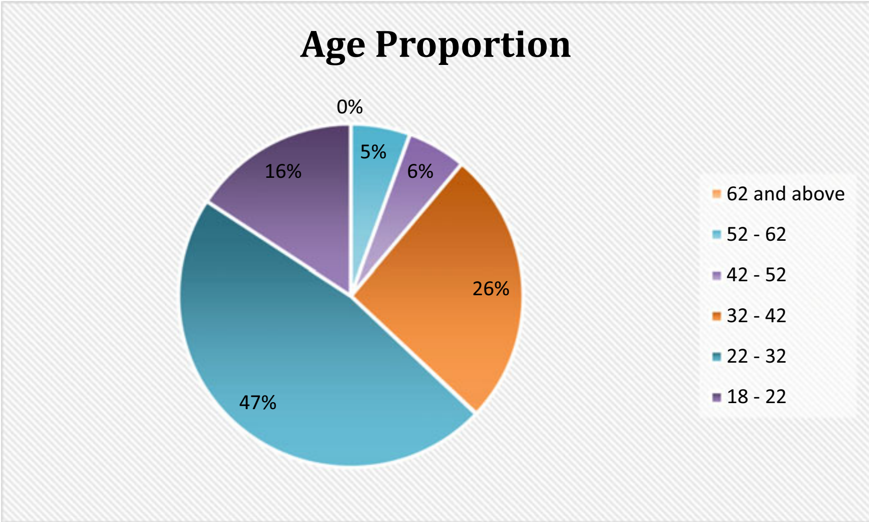

Fig. 4 Age proportion of survey respondents

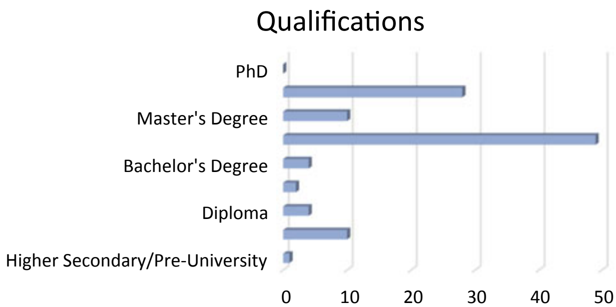

Fig. 5 Qualifications of participants

h. **Internet Usage and Online Shopping Frequency**

In this section, the survey questions were intended to elicit information about the number of hours that people generally spend on the Internet. The results shown in Fig. 8 indicate that the majority of respondents spend up to five hours on the Internet on a daily basis. Noticeably, up to 30% participants engage with online activities somewhere between five to ten hours every day. This can be considered as a significant amount given that an ordinary person tends to spend 7–8 h in bed, another 7–8 h on work or study; thus, time spent on the Internet could take up the rest of their waking hours. Naturally, this does not take into consideration those who use the Internet in their jobs, such as social media managers or content copywriters.

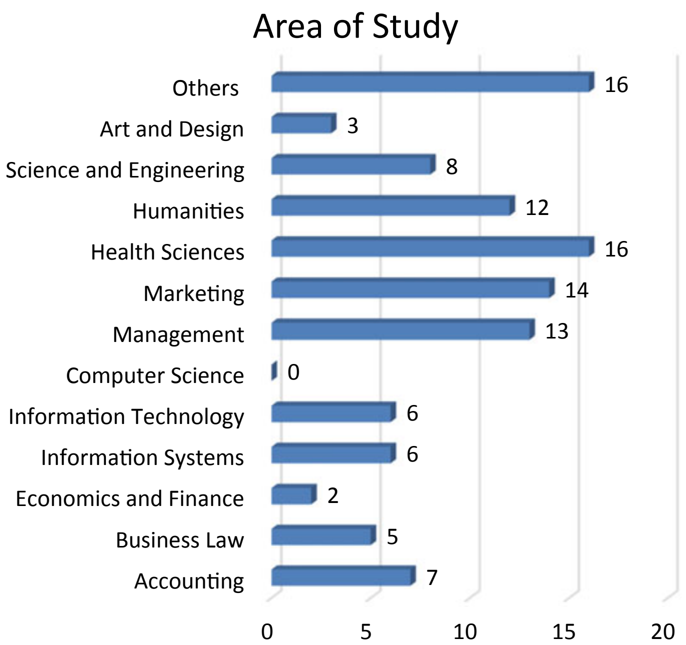

Fig. 6 Participants' areas of study

Fig. 7 Occupations of participants

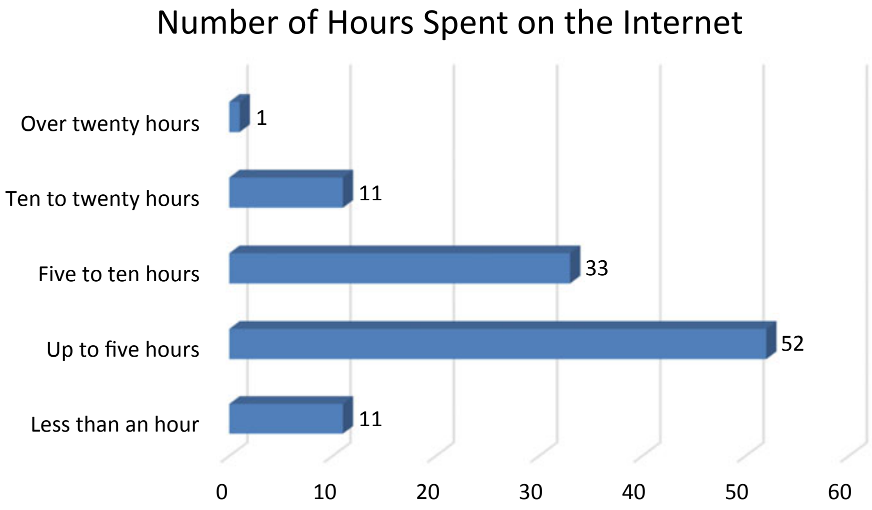

Fig. 8 Number of hours spent on the internet

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Of this number of hours spent on the Internet, it is of interest to know how much time respondents spend on online shopping. Up to 83% of participants indicated that they often spend very limited time of less than an hour daily on purchasing products or services online. However, 13% of the sample spend up to five hours of their day engaged in online shopping (Fig. 9).

Another point worth making here is that e-commerce operators have a very limited amount of time to attract and win customers given the many interesting and exciting online activities vying for their attentions in the hyperconnected webs nowadays.

i. **Categories of Products Purchased**

Overall, the products purchased vary greatly and range from computer software to electronic tickets to clothing items (Fig. 10). The most prevalent category is undoubtedly clothing with more than 83% of participants reporting previous online purchases.

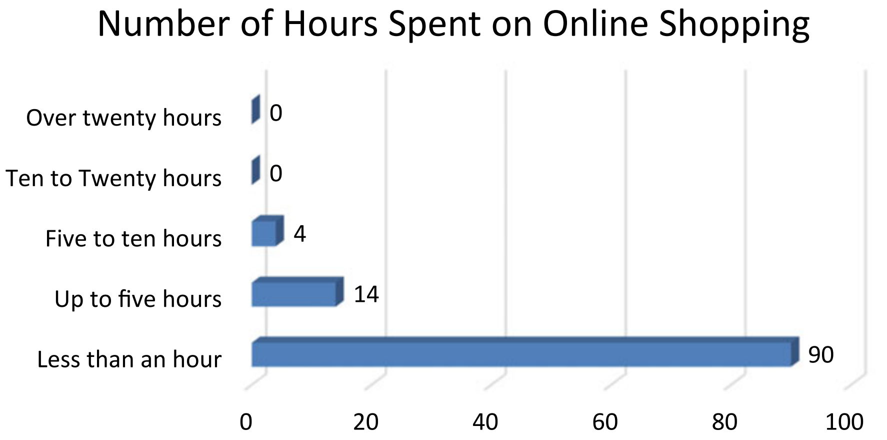

Fig. 9 Amount of time spent on online shopping

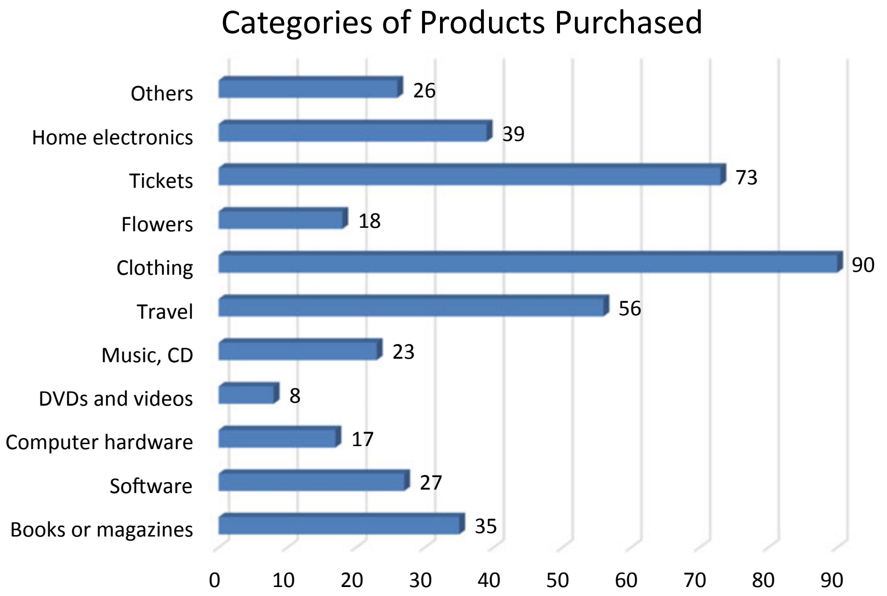

Fig. 10 Categories of purchased products

This result is somewhat surprising given that the biggest marketshare component in Australia at the moment goes to grocery operators (Miller, 2019). However, it is certain that fast fashion brands have disrupted the way people consume fashion products. Fashion trends are changing at an exponential rate and the cost of clothing items could be low due to cheap overseas labour.

j. **Factor Analysis**

Despite the Sustainability factors did not produce a favourable result to be considered for this study. Regardless of an acceptable Alpha, KMO and Bartlett test result, the factor loading is not significant enough and prone to cross-factor loading. Given the industry has become very dynamic only during the last decade, it can be inferred that people might not have yet developed a strong opinion about sustainability. In order to overcome this issue, a thematic analysis (Fig. 11) was conducted of the open-ended questions formulated specifically for the sustainability theme.

The concept of sustainability in online shopping seems to be up for debate at a consumer level. Many respondents indicate that online shopping has enabled them to purchase more sustainable options at a more affordable costs and make it more easily accessible. On the other hand, many others express the concern that the shipping activities involved with online shopping contribute significantly to global carbon emissions, thereby offsetting the benefits of a more sustainable product such as to-go coffee or reusable metal lunch boxes. Furthermore, some respondents even mention that online shopping and Internet marketing bombards them with more wants and needs. As a result, consumers are encouraged to purchase more, rather than use up what's currently on hand, to keep up with peers or to think that newer, shinier items will make them happier. Nonetheless, the available natural resources might not be

Fig. 11 Thematic analysis for sustainability factors

Table 1 Factors loadings for all variables

Items	Effectiveness & Efficiency	Reduce Environmenta l Impacts	Scams and Products Delivery
Meeting my satisfaction and goals	0.768		
Quick to complete my tasks	0.759		
User friendly	0.755		
Reduce carbon footprint		0.887	
Reduce climate global warming		0.866	
Reduce Air Pollution		0.866	
Increase scams concerns			0.680
Delay in delivery of Products			0.679
Fail to receive the Products			0.675

able to keep up with this rising consumerism and are on the verge of exhaustion while creating more waste around the world in the absence of closed-loop initiatives.

An overall factor analysis was also conducted on all factors across the board for cross-referencing and identifying most of the factors influencing Australian Internet shoppers.

The results of the factors analysis are supportive since they indicate the emergence of three statistically distinct factors (Table 1). Most important is the group of highest loading factors. Although a separate factor analysis by itself does not produce a favourable result, when done together with all factors it has led to a clearer picture of where Australians consider online shopping to be sustainable. All in all, it is deemed to bring about a decrease in the carbon footprint, climate change and air pollution. These factors are labelled as a new factor, which is "Decrease in Environmental Impacts".

In short, over the course of this research, a number of findings and background characteristics have been identified. Overall, the majority of respondents are female, either studying or with a Bachelor qualification and employed as administrators. In regard to Internet usage, 48% spend up to five hours every day but very little time is actually spent on online shopping. Of all listed product categories, clothing items are the most popular. The factor analysis has given rise to a set of new factors, and most important of them all is reducing environmental impacts.

To a large extent, these findings paint a bigger picture of factors that currently influence online shopping behaviours in Australia. They are also taken into consideration to develop appropriate recommendations for stakeholders.

In light of all the foregoing discussions, it is safe to conclude that technology breakthroughs have disrupted many things that people have been accustomed to, especially in the way that one communicates and trades with another. Internet marketing and online shopping are only two of the myriad technical advancements that make human life easier. These two alone have brought about numerous changes in how marketers are talking to consumers and encouraging them to consume more of their products or services. As a result, both sectors are expected to see favourable augmentation in years to come in Australia. It is easier than ever before to purchase a foreign product just with a mouse click. In a way, this could be for the better or for the worse. The world has become hyperconnected: streams of merchandise and people constantly flow through from a trade agreement to another, and from one political jurisdiction to another. Simultaneously, however, people are confronting unprecedented risks when talking and doing business with people they might not see in person before or ever. In the Australian setting, business operators who wish to succeed in the e-commerce sector need to consider a number of factors such as reliability, feasibility, and usability of the websites alongside sustainable business practices. At the end of the day, the digital experience is still a human experience. Some might argue it makes it easier to reach a wider audience, while others might find it hard to communicate in the absence of a face-to-face interaction.

5 Discussion

The above section has shed light on how people in Australian perceive e-commerce retailing activities. The research has revealed the most important factors that need to be considered when designing a website that offers a successful online shopping experience. These factors range from feasibility, usability, convenience, saving, to cybersecurity concerns to potential environmental impacts. It is necessary to note that the demographic characteristics might carry heavy weights in terms of these factors.

Such a homogenous demographic might represent one of the limitations that this study is bound by, which will be discussed in depth in this section. This section ties the aforementioned discussions together by addressing the research questions stated in Sect. 3. Additionally, it brings the study to an end by providing a summary of issues of interest and offering recommendations to various stakeholders.

k. **Summary of Research**

Ultimately, this study was intended to investigate and determine the factors that encourage Australians to spend more online. Given the expansion of Internet marketing and the online retail sector in Australia, the insights provided by this study can benefit business research and businesses which need to stay ahead of the game if they are to be competitive. This research was guided by a research question which will be addressed in detail at the end of this section. Most of the data was collected using a qualitative strategy. A hybrid research method combining qualitative and quantitative approaches was adopted.

Most up-to-date industry reports suggest that both Internet marketing and e-commerce sectors in Australia are bound to experience a massive growth in the next decade due to a wide variety of factors. These include an accelerating increase in paid digital media, the proliferation of telecommunication services, technological breakthroughs together with the convenience, cost -effectiveness, time-saving, and multiple supply chain management solutions that it provides to both consumers and suppliers. However, these sectors also have certain downsides stemming from societal issues and most importantly the instability of global factors such as politics and economies.

The literature review indicated that consumer purchase behaviour is heavily dependent on the purchase intention, which is a set of beliefs or perception that customers form over time. In the online environment, the psychological factors contributing to this intangible perception includes a subjective evaluation of whether a website is trustworthy, secure, time-saving, cost-saving, or convenient. Most importantly, sustainability has been of paramount concern more than ever before regardless of the industry. Sustainability issues are a significant presence throughout the entire supply chain of online purchase consumption from supplier shippings issues to end-of-life-cycle for consumer products. Nonetheless, this study suggested that the issue of sustainability in Australian online shopping is relatively controversial given a number of opposing ideas about the carbon footprints left by the shipping, although it is more sustainable for people to acquire something online without having to board a plane to a foreign country. Largely, the findings in this study suggest that Australian shoppers perceive e-commerce activities might contribute to reducing the carbon footprint, global warming and air pollution.

As mentioned earlier, the objective of this paper is to answer the research questions restated below:

- What are the advantages or disadvantages of online shopping with regards to improving sustainability awareness?

This research question concerning sustainability has been resolved by this research result in that there are pros and cons of almost everything and online shopping is no exception. Although it is virtually impossible to achieve a zero environmental footprint, necessary actions have to be taken to reduce its impact to a minimal level. It could be more a matter of personal values and perception when it comes to sustainability, so further research might be able to clarify this concern for future reference.

1. Limitations and Suggestions for Future Research

This section will discuss several limitations of this study and suggests how future research might be able to overcome the shortcomings and add to the body of knowledge. First and foremost, the chosen methodology which is the survey, is a self-reporting mechanism that is prone to inaccuracy. The rationale is that while in a state self-reporting, individuals often force themselves into a conscious state which is easily manipulated by many external factors such as perceived acceptable behaviours, socially expected belief or social norms. As a result, there is a strong possibility that participants could be subject to cognitive bias (Lewinski et al., 2014).

Additionally, despite the many benefits of online surveys, geographic distance deprives the study of many important factors such as facial expression, first impression of a particular part of the study, and the researcher's inability to resolve misunderstanding in regard to certain questions. Therefore, less biased data collection method such as biometric application in an A/B testing might provide future research with more accurate result.

This study has a focus on quantitative data collections and was able to reveal certain findings via these methods. In saying that, future academics could consider undertaking further qualitative research to acquire a more comprehensive understanding of the outlined factors and of what Australian shoppers have to say about online shopping.

As a consequence of the sampling frame, the research has drawn conclusions mainly from the Western Australian population, without considering many other major metropolitan cities. Thus, researchers are encouraged to conduct future research with a more diversified population, including more rural areas where Internet marketing and online shopping might be less prevalent to reveal even more findings. Consumers from less-developed countries in terms of economy and technology might have behaviours that differ from those indicated by the findings of this study. Thus, further research in this area might contribute greatly to the cultural study from business and Information Technology implementation perspectives around the world.

Lastly, as mentioned in Sect. 5, this study was not successful in generating a concrete and significant enough factor purely for sustainability factors given the diverse opinions of participants.

m. **Recommendations**

Based on the findings of this study, the author suggested a number of recommendations for different groups of stakeholders from business operators to consumers, which are depicted in Table 2.

6 Conclusion

In light of all the foregoing discussions, it is safe to conclude that technology breakthroughs have disrupted many things that people have been accustomed to, especially in the way that one communicates and trades with another. Internet marketing and online shopping are only two of the myriad technical advancements that make human life easier. These two alone have brought about numerous changes in how marketers are talking to consumers and encouraging them to consume more of their products or services. As a result, both sectors are expected to see favourable augmentation in years to come in Australia. It is easier than ever before to purchase a foreign product just with a mouse click. In a way, this could be for the better or for the worse. The world has become hyperconnected: streams of merchandise and people constantly flow through from a trade agreement to another, and from one political jurisdiction

Table 2 Recommendations to impact online shopping behaviour in Australia

Stakeholders	Recommendations
Business Operators	Implement sustainable logistics initiative that aims at reducing air pollution, carbon footprint and global warming, and communicate such to consumers.
Policy-makers	Review and implement international relations policy in a diplomatic manner to encourage both domestic productivity without hurting oversea business partners. Carefully monitor cyber trends worldwide to stay updated and inform ordinary users in a timely manner.
Academics	• Conduct further research in a non-self-reporting manner to bridge any gap in this research • Replicate study in less-developed nations (i.e. lower GDP per capita) to obtain a more comprehensive body of knowledge.

to another. In the Australian setting, business operators who wish to succeed in the e-commerce sector need to consider a number of factors, especially sustainable business practices. At the end of the day, the digital experience is still a human experience. Some might argue it makes it easier to reach a wider audience, while others might find it hard to communicate in the absence of a face-to-face interaction.

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Users' Attitudes Toward the Adoption of Green Information Technology by Vietnamese Business

Thi Hoang Tham Do

Abstract People now have seen many negative consequences of degrading the environment or exploiting natural resources in many places around the globe. In response to that problem, sustainability development has become an essential achievement in all the development industries to conquer the worldwide goals. Sustainability development commits people to acknowledge the place of human beings within the ecosystem by considering the long-term impacts of their actions. One of the primary questions that drive the research is: *What is the awareness of green IT factors in business adoptions in Vietnam?* The question provides information and opens a discussion both of the green IT factors and the Vietnamese users' attitudes toward the adoption of green IT by businesses in Vietnam. Another primary question is: *What are the advantages and disadvantages of green IT use in Vietnam?* It seeks to resolve not only the positive but also the negative details of implementing green IT solutions which depend on the Vietnamese culture. The research works revealed several new factors that were resulted in means of an analysis tool SPSS (Statistical Package for Social Science). The new factors for the awareness were 3Rs, Environmental, and Green design; the new factors for advantages were: Environmental, Organisational, and Economic; the new ones for disadvantages were: Social pressure, and Economic pressure. Lastly, we acknowledge several potential limitations that might restrict the generalization of the results. They are time constraints, scope of the research, and lack of guidance for participants, interviewer, and sample populations. Those limitations open opportunities for future research which can enrich the valuable findings from the research.

Keywords Green information technology · Vietnamese business · Users' attitudes

T. H. T. Do (✉)
School of Management, Curtin University, Perth, Australia
e-mail: dothihoangtham@gmail.com

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1 Introduction

For millions of years, Earth has been providing humans and other creatures with the environment and resources necessary for survival. However, the rapid increase of populations and the Industrial Revolution has meant that humanity's ecological footprint has exceeded the Earth's capacity and caused negative impacts of climate change globally. Specifically, going by the current pace of mining the natural resources, it would need the capacity of 1.6 planets to provide sustainability (WWF 2016). Furthermore, according to Fritzsche et al. (2018), in the 21 century, there has emerged a "fourth industrial revolution", known as "Industry 4.0", where digital technologies, such as artificial intelligence, big data, virtualization and virtual reality, 3D-printing and intelligent or autonomous machinery in manufacturing have been significantly developed. Therefore, the digital transformation of industrial processes should be considered in the light of mitigating climate change and promoting sustainable energy.

Green information technology (green IT) is the strategy practice or any tools that improve and foster environmental sustainability. According to Nidumolu et al. (2009), green IT practices (green computing techniques) can reduce energy usage and minimize the environmental impact. Understanding the urgency of the issue, the governments of many developed and developing countries have devised the plans and implementations of green IT in business operations. Particularly, huge technology companies, such as Apple and Samsung, who are producing millions of digital devices worldwide every year.

This research was conducted in Vietnam and will provide an understanding of both the green IT factors and Vietnamese users' attitudes toward the green IT adoption in business in Vietnam, a lower middle-income country. The country's economic growth is establishing an important foundation for sustainable development in the years ahead.

2 Background

According to the Living Planet Report (WWF 2016), humanity's ecological footprint has exceeded the Earth's capacity. Another interesting point concerns the biodiversity index reported by the same organization, showing that more than 50% of the populations of other species continue to decline. All over the world, more than 48% tropical and subtropical forests have been lost. The Intergovernmental Panel on Climate Change (2014), found that greenhouse gas emissions have almost doubled. The impacts of climate change have become increasingly noticeable. Therefore, in the new global economy, green information technologies have become a central issue for sustainable operations in business.

Many giant organisations such as Apple and Samsung have started to establish their own production cycle which uses recycled materials rather than natural resources (Apple 2017; Samsung 2019). Apple (2017) indicated that the company has been contributing around 30% increase in recycled fiber content in iPhone 7 packaging, which has significantly reduced the use of plastic and virgin fiber. In 2017, the company also mentioned that 100% of the paper in their packaging was sourced from responsibly managed forests, controlled wood or recycled sources. Similarly, Samsung (2019) established the Asan Recycling Centre in 1998 to recycle waste electrics in a closed-loop recycling process. In 2017, the Centre processed 357,000 units of refrigerators, washing machines, air conditioners, and IT devices, separating 25,365 tons of major metals (steel, copper and aluminium) and plastic to be recycled. These great efforts have benefitted the planet and the economy.

2.1 Sustainability

In recent years, there has been an increasing concern about sustainability expressed by customers all over the world. To global manufacturers, sustainability is no longer an optional policy for production processes these days. Sustainability is a state of equilibrium between production and natural resources and nature where its exportation of uncompensated anthropogenic environmental risks to future generations is unacceptable (Hueting and Reijnders 1998). Erek et al. (2009) defined sustainability as a survival assurance. Brundtland (1987) at the World Commission on Environment and Developments stated that sustainability seeks to meet the needs and objectives of the present without compromising the ability to meet those of the future. Moreover, the UNT Health Science Center (2018) suggested that sustainability is not associated only with environmental conservation, but it is also about the well-being of people and the health of our communities. Despite the variants, no matter how the sustainability is defined, or how the context of sustainability is viewed, all definitions share a core value of sustainability: that resources need to be conserved in order to be available to all generations.

The history of sustainability has been continuously changed by the development of human communities. The concept of sustainability will persist as long as humans exist it reflects a concern for the future of our resources. The exponential human population growth has produced greater demands for natural resources such as energy, food, housing and land, as well as a significant increase in waste by-products. Also, Satterthwaite (2009) show the implications of the human population growth: unsustainable growth and the increase in consumers and in their levels of consumption which drove the growth in greenhouse gas (GHG) emissions that caused climate change. According to Engelsiepen (2010), Rachel Carson took on the powerful and robust chemical industry in her globally acclaimed 1962 book, Silent Spring, where she demonstrated the negative impact that humans have had on nature. That was the first time that people would begin to have some idea about sustainable production. In 1949, an American geophysicist, Dr. Hubbert (1949), predicted that fossil fuel production would reach its peak in 1970 and would then begin steadily declining against the rising energy demands. The word' sustainability' began to be globally noticed from the 1980s as a term referring to sustainability of all living systems in a single living planetary system. In the 21st century, sustainability awareness has become global. A worldwide collaboration between international business and science, Copenhagen Climate Council, issued a statement that while the society and economy have developed and thrived, the climate system seemed to be already moved beyond the patterns of natural variability (Richardson et al. 2009). Today, when the risk has been raised to a significantly high level, there is a hope that with the rapidly advancing technologies, the current and next generation will have some means of achieving successful sustainable practices.

2.2 Triple Bottom Line

Empirical studies on sustainability have mainly investigated the components of sustainability and how they could affect the planet in the future. Ajmal et al. (2018) explained the convergence of the three pillars of sustainability how it should be performed in business. There are three main components of sustainability: Society, Environment, and Economy. In the business sense, those three factors are known as the 'Triple Bottom Line'; that is, they are about People, Planet, and Profit. Erek et al. (2009) described the triple bottom line "as a framework for companies to measure and report their performance and organizational success in relation to these pillars". The concept of sustainability would help them to minimize the business's negative impacts on people, societies and the environment.

It has been claimed that thinking about profit without relating it to economic and social impacts is short-sighted and counterproductive. The financial bottom line remains the essential factor for businesses, but the profits will help empower and sustain the community as a whole. Additionally, as discussed at the 2005 World Summit on Social Development (United Nations 2005), the main objectives of the triple bottom line are: to eliminate poverty, modify or adjust unsustainable patterns of production, and preserve natural resources. In essence, the triple bottom line is the primary objective of sustainable development; Nidumolu et al. (2009) mentioned that the approach will yield both bottom-line and top-line returns. Although the approach may initially be costly, companies will end up with tremendous savings in the long term by reducing the number and amount of resources being used. Moreover, Nidumolu et al. (2009) indicated that the approach can bring greater revenue from better products and opportunities of creating new business models.

Unfortunately, Ajmal et al. (2018) and several other researches indicated that most of the initiatives have so far emphasized only the economic and environmental aspects; they have been overlooking the society pillar of sustainability. However, the entrepreneurs and stakeholders today have had to modify their thinking according to the triple bottom line. It has been claimed that thinking about profit without relating it to economic and social impacts is short-sighted and counterproductive. The financial bottom line remains the essential factor for businesses, but the profits will help empower and sustain the community as a whole. Moreover, the People bottom line is where employees as well as the community's well-being are taken into consideration. It comprises offers of health care, good working hours, a healthy and safe workplace, opportunities for advancement and education, and no exploitation of employees.

2.3 Cooperation Social Responsibility (CSR)

As part of sustainability in business operations, corporate social responsibility (CSR) is defined by Jen Boynton, vice president of member engagement at 3BL Media, as a simple way for companies that impacts of their business operations is to take responsibility for the social and environmental impacts of their business operations (Caramela 2018). Besides the matter of unfair wages, human trafficking, forced or child labor, there were some highly destructive incident again emphasises to all organisations that CSR (CSRHub) is essential and compliance can be a matter of life and death. For example, the 2013 Rana Plaza disaster in Bangladesh killed 1,134 textile workers and injured hundreds of survivors (Islam 2018). Basically, the concept of CSR involves investigating the role of business in society and encouraging the positive societal outcomes of business activity. CSR is a measurement of social responsibility to improve a company's sustainability performance in four respects: community, environment, employees, governance. In the other hand, Islam and Deegan (2010) reported that due to the absence of regulatory expectations, CSR activities were not regular or frequent; companies engaged in CSR when they were under greater pressure from public and social movements. However, many organisations now have to comply with specific social disclosure legislation. The Parliament of the United Kingdom (2015) requires companies to take action to deal with modern slavery, child labour, and human trafficking throughout their production chains. Moreover, according to the Government of India (2013), section 135 of the Indian Companies Act, Indian companies are required to spend 2% of their pre-tax profit on CSR.

CSR is more than just a business trend or fad. CSR is critical for every organisation to maintain the stability of its triple bottom line, and to ensure business activities have positive social and environmental effects associated with the way the business operates. CSR activities have a positive influence on brand/company evaluations, brand choice, brand recommendations, customer satisfaction and loyalty, customer-firm identification, and consumers' attributions in a product-harm crises situation. Additionally, Seventy percent of young employees disclosed that one of the important factors influencing their choice of workplace is the organisation's commitment to CSR, as found by a recent Deloitte survey (OHIO University 2018). Employee engagement is also related to a company's CSR reputation.

Bhardwaj et al. (2018) demonstrated two types of CSR: company ability relevant CSR (CSR-CA) and company ability irrelevant CSR (CSR-NCA). The CSR-CA strategy influences corporate ability that would help the organisation's performance, improve their product development and manufacturing capabilities. On the other hand, a CSR-NCA strategy does not improve corporate ability, but the company invests in social initiatives that will improve the lives of others. Regardless of the type of CSR in which an organisation invests, consumers are likely to appreciate companies who engage in CSR, and they are willing to pay a higher price for their products. Additionally, CSR is a broad concept that can be implemented differently by every organisation. However, the main purpose of CSR is to encourage the positive outcomes of business activity for the economy, society, and environment. The Corporate Finance Institute (2018) categorizes CSR according to four responsibilities: environmental responsibility, human rights responsibility, philanthropic responsibility, and economic responsibility.

According to Rangan et al. (2012), CSR requires organisations to take responsibility for the community and environment. Organisations not only need to support the local workers by understanding their local culture, but also need to comply with environmental protection policies. Specifically, the CSR approach encourages organisations to take steps to implement sustainable business practices by developing products that use less energy or packaging. This helps to decrease the utility bills and cost of materials. Innovation is always necessary for business and society; hence, CSR encourages research and development to innovate and produce new products. Moreover, CSR is playing an important role in brand differentiation. Many companies were able to find their voice in incorporating the company's values into their business models by embracing CSR which promotes and maintains fair competition among business competitors. Furthermore, it has been proven that the role of CSR has been one of the most effective means of communication with target customers. In other words, CSR increases customer engagement in a new way. Last but not least, CSR helps companies attract and retain top-quality talent. As environmental and social responsibilities are undeniable in every activity, employees often expect their employers to share the same ethical behaviour and have values that align with their own. If employees are encouraged to engage in CSR initiatives, their motivation, loyalty and delivery quality will increase.

2.4 Green Information Technology (IT)

One of the most considerable challenges for all organizations nowadays is how to efficiently establish green IT in their business operations. Green IT stands for 'green information technology' and is the practice of environmentally sustainable computing. Green IT practice aims to reduce the negative impacts of IT operations on the environment. It applies to all stages in the product life cycle including designing, manufacturing, operating and disposing of computers and computer-related products in an environmentally friendly manner. Nidumolu et al. (2009) reported that green IT is the practice, strategy or any tools that improve and foster environmental sustainability. Understanding green IT is good not only for all organizations but also for individuals who are living by using Nature's resources.

Reported by Young (2017) and Safaei et al. (2017), nowadays an average of three connected devices are owned by the typical digital consumer and the number was predicted to be increased to nine by the end of 2025. The number of technology devices has been exponentially increased and definitely impact on our environment. Therefore, green IT or green computing is playing an essential role in the lives of human beings. Businesses and individuals should be aware that their production processes need to be environmentally friendly. Many industries and organizations have transformed their business operations and targets by embracing green technology. For instance, Bernard (2019) reported some technology innovations from IBM in the next five years with the mission of addressing the planet's food crisis and decreasing the use of fossil fuels and the carbon emissions from chemical processes. According to Bhardwaj and Neelam (2015), a green technology of products, equipment and systems need to satisfy these criteria: (1) minimize the deterioration of the environment; (2) produce none or minimal greenhouse gas emissions and promotes healthy and improved environment for all forms of life; (3) recycle the use or energy and preserve the use of natural resources; and (4) promote the use of renewable resources.

Besides responsibilities of business owners towards the environment, "green consumption" is also playing an important role in the protection of the environment. Users' awareness of green IT has a significant influence on preventing or decreasing environmental damage by making decisions when purchasing or using technology products or services. Figure 1 illustrates the six factors that the users should be aware of when they consider green IT.

According to Belu et al. (2016), the green IT design of products or services must have a reduced environmental impact throughout their life cycles. The whole process of developing green products needs to ensure a sustainable future for all. Moreover, green IT considers the health and safety of communities and consumers. The green development of products should take into consideration the air pollution, carbon footprint, climate global warming as well as consumption and waste of resources. Also, green IT awareness is not only displayed on the product details, it is also reflected in the way that products are manufactured and whether they have used less energy, and reduced waste and toxins, and the consumption of raw materials. Additionally, input materials have been receiving considerable attention from scientists, engineers, technologists, and industrialists. For green IT, the three characteristics of materials are important: recycled, recyclable, and renewable. Haghi et al. (2019) stated that the recycling process involves changing materials into new products to prevent waste of potentially useful materials, thereby reducing the consumption of fresh raw materials.

There has been sufficient evidence were produced to conclude that green IT, an environmentally friendly technology that protects the environment and conserves natural resources, is an increasingly important technology trend that cannot be ignored. As in Fig. 2, it shows four advantages of Green Information Technology. Products, equipment and systems that promote green technology do not emit anything harmful to the environment. Therefore, they can reduce the carbon footprint, GHG emissions and environmental pollution. EVgo (2019) showed that Electric vehicles

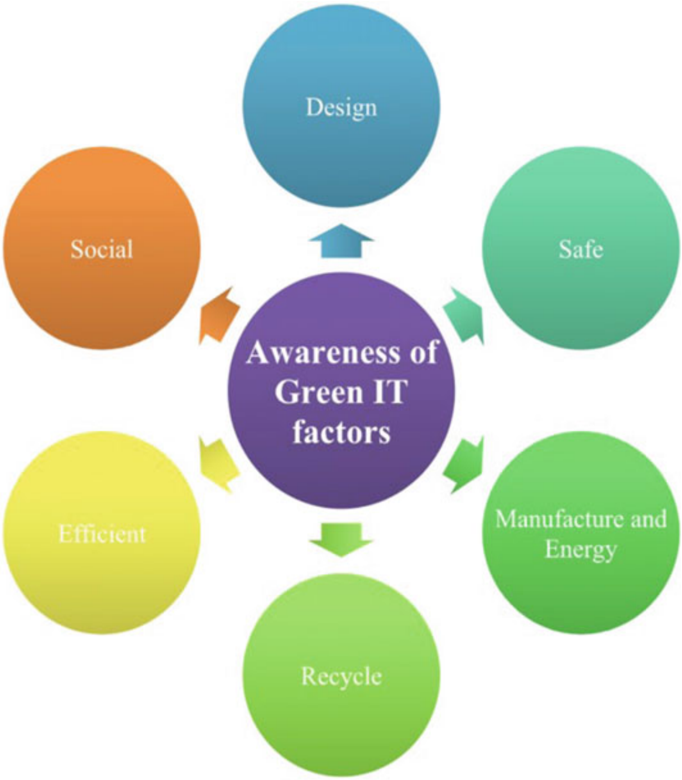

Fig. 1 Green information technology awareness (prepared by the author) (Belu et al. 2016; Haghi et al. 2019)

are one of the inventions reflecting green Technology. Furthermore, as an advantage of green technology, electric vehicles also provide significant savings on charging and maintenance costs. Moreover, the products of green technology will not exploit the natural resources; therefore, the production never runs out by using renewable resources. In the Environmental Responsibility Report produced by Apple, the company announced that all its data centers would be 100% powered by renewable energy from January 2018, generated by wind, solar, low-impact hydro, and biogas fuel cell power (Apple Inc. 2018). Additionally, green IT also promotes eliminating toxins, harmful chemicals to users and environment. So far Apple Inc. (2018) has eliminated six toxins from their products: beryllium, mercury, lead, arsenic, pvc and phthalates, and brominated flame retardants. Furthermore, Madison (2019) and James (2012) highlighted that green IT helps to improve a company's brand and products, attract top-quality talent and facilitate long-term financial success.

On the other hand, green technology is still a novel technology and its widespread consequences are unpredictable. Figure 3 indicates that Green Information Technology has the main 2 disadvantages: cost and failure. Although the technology

Fig. 2 Advantage of green information technology (prepared by the author) (Apple Inc. 2018; EVgo 2019; Madison 2019; James 2012)

Fig. 3 Disadvantage of green information technology (prepared by the author) (Shaner et al. 2018; Bhardwaj and Neelam 2015)

offers undeniable positive benefits to the environment and living things, its associated changes and challenges are still unknown and require considerable efforts. Many people believe that the implementation of Green IT would inflate costs. Shaner et al. (2018) demonstrated in a study of Energy and Environmental Science that the wind and solar energy alone can provide about 80% of the recent US annual electricity demand, but there were considerable investments on construction and maintenance to avoid any major blackouts. Besides the high costs.

Bhardwaj and Neelam (2015) also pointed out several other disadvantages of another barrier preventing organisations from adopting green technology is that there are insufficient or inadequate alternatives of chemical or raw material resources which have been easy to be obtained by exploiting the natural resources. In order to promote green technology growth, researchers and experts need to identify and remove these risks, although it is a complicated and long-term process.

2.5 Green IT and Sustainability in Developed and Developing Countries Including Vietnam

Both developed and developing countries will have serious impacts on the ecosystem services and natural resources if they continue with their business-as-usual economic growth and development without long-term green-growth policies. OECD (2013) suggested that green-growth policies will help nations promote the protection of the environment and sustainable use of scarce natural resources while continuing to achieve improvements in living standards and reducing poverty. While developing countries are in the process of designing green-growth strategies, there are some implementations in developed countries such as the National Strategy and Five-year Plan for Green Growth in Korea and the Growth Strategy for 2020 in the European Union. OECD (2012) highlighted that many developing countries face different and more difficult policy choices than developed countries in defining and implementing green growth strategies. In countries with high levels of rural poverty, bringing more land under cultivation because of the high environmental cost becomes highly difficult for them and so it seems feasible for them to continue exploiting the existing cultivated land.

A growing number of countries, including developed and developing countries, actively promote the production and use of biofuels which contribute little to reducing GHG emissions, despite the environmental risks of biodiversity, land conversion and soil disturbance. The OECD (2013) reported that there has been a steady increase in the percentage of green patents throughout the world in recent years. Green innovation is an important way to accelerate the transition to greener growth. An unclear question for developing economies is how to encourage and foster such innovations given the importance of demand as a trigger of innovation. While the international transfer to green technologies in developing countries has been greater in recent years, they have remained minor compared to the transfers between developed countries. These transfers have taken significant initiatives to share international knowledge and technology-oriented agreements. In order to have a comprehensive measure of sustainable consumer behavior in multiple areas related to housing, transportation, food and goods, National Geographic has partnered with GlobeScan (www.globescan.com) to conduct a global analysis, which is called National Geographic's Greendex, to measure and monitor consumer progress towards environmentally sustainable consumption (GlobeScan 2014). The results were obtained via by a quantitative methodology which involved Internet surveys of approximately 1000 consumers in each of the 18 countries who represent both developed and developing countries: Argentina, Brazil, China, India, Mexico, South Africa, Australia, Canada, France, Germany, Great Britain, Hungary, Japan, Russia, South Korea, Spain, Sweden, and the USA. There was an increase in 2014 in global concern about environmental problems by 5 from 56% in 2012. Additionally, 65% of consumers overall believed that most scientists were convinced that human activity causes climate change and nearly half of the consumers in the 18 countries surveyed in 2014 believed that global warming will negatively affect their own lives.

2.5.1 Green IT and Sustainability in Developed Countries

According to GlobeScan (2014), South Korea is the only developed country ranked among the top five with the highest Greendex overall rankings in 2014. It obtained a score of 55.7 and was very closely followed by other developing countries, Brazil and Argentina, correspondingly at 55.5 and 55.4. Interestingly, despite being one of the richest nations in the world, United States consumers' behavior ranked as the least sustainable since the inception of the Greendex study in 2008. The Global Footprint Network (2013) concluded that we need to have four Earths to support the global population if everybody were to live like America residents, while only needing 1.2 Earths if everybody were to live like the typical resident of China.

According to Birol (2018), in the International Energy Agency's (IEA) Renewables 2018 report of the share of renewables in total final energy consumption, Brazil has the highest share of renewables in the world's largest energy consumers by far almost 42.1% of total final energy consumption in 2017 and the percentage was predicted to be 44.3% in 2023 (Birol 2018). However, Seydel (2015) claimed that Iceland is the world's largest clean energy producer per capita with almost 100% energy coming from renewable sources such as geothermal, hydroelectric power plants. In Energy in Sweden (2018), Sweden's renewable energy shared 54% of total energy consumption and continued to increase with the goal of eliminating fossil fuel usage and having100% renewable electricity production by 2040 (Swedish Energy Agency 2018). Their top renewable sources are hydropower (water) and bioenergy.

Christensen et al. (2011) found that green energy adoption is a more daunting challenge for developed economies. Hundreds of millions of consumers in developed countries are familiar with the existing technologies and they would not find green technologies a concern for the environment. Even though there are some convenient, low-cost, and pervasive energy infrastructures in developed countries, the green technologies adoption needs to comply with the rules of innovation, produce more affordable or better performing applications to displace their competitors in order to be successful, and thrive in the developed world.

2.5.2 Green IT and Sustainability in Developing Countries

Birol (2018) showed that China leads absolute growth in renewable energy consumption by 2023 with the largest capacity of hydropower (92.2 Mtoe) (Birol 2018). That would be the result of policies to decarbonise all sectors and reduce harmful local air pollution. Although China is the most air polluted country in the word, it is also the world's biggest investor in renewable energy. Slezak (2017) found that China owns five of the world's six largest solar-module manufacturing firms; the largest wind-turbine manufacturer; the world's largest lithium ion manufacturer; and the world's largest electricity utility.

According to the Greendex result in 2014, India and China have continuously stayed in the highest position at 61.4 and 57.5 of overall ranking since 2012 (GlobeScan 2014). All seven developing countries were in the top half of the 18 surveyed countries. In order of ranking, they are: Brazil (55.5), Argentina (55.4), Mexico (55), Russia (53.3), South Africa (52.2), and Germany (51.3). Green technology in developing countries has the added benefit of contributing to the fight against carbon emissions. There were the top greenhouse gas emitters excluding land-use change emissions, according to the Emissions Gap Report 2018 of the United Nations Environment Programme (UNEP 2018), indicates that half of the carbon dioxide emissions are from the developing countries, whereas China produced the most carbon dioxide emissions (26.8%), almost double that of the United States at 13.1%.

Reported by the International Energy Agency (2018) that the change in energy-related CO2 emissions by region, while the United States' emissions experienced a significant drop by 0.5% by replacing coal with gas and renewables-based electricity generation, China and most of the developing countries accounted for two-thirds of the global increase in carbon emissions. (Christensen et al. 2011) predicted that by 2030 developing economies will produce almost double the carbon dioxide emissions of developed countries if they keep the emissions at the current rate.

2.5.3 Green IT and Sustainability in Vietnam

Despite the income gap between different classes of the population in Vietnam is widening and challenges from environmental and climate change have become increasingly harsh, sustainable development is indisputably the goal of any country in the world and Vietnam is no exception. The economic growth has been laying an important foundation for sustainable development in Vietnam in the years ahead. Thang (2016) highlighted some actions which the government of Vietnam has taken towards sustainable development. They are "National Plan for Environment and Sustainable Development 1991–2000: Framework for Action" (1992), Strategic Orientation for Sustainable Development (Vietnam Agenda 21) (2004), and Viet Nam Sustainable Development Strategy for 2011–2020 (2012).

In regard to society aspect, Vietnam has progressed impressively in human development and multidimensional poverty reduction. Being in the top highest fourth countries of the Medium Human Development group at 0.0694 in 2017, Vietnam needs only an additional 0.006 points to join the High Human Development group. Specifically, Viet Nam's Expected Years of Schooling has increased from 7.8 years in 1990 to 12.7 years which was higher than the average of the Medium Human Development group at 12.0 in 2017. Interestingly, Vietnam generally outperformed its counterparts on the health component of the HDI. The life expectancy at birth (76.5) was higher than the average (76.0) of the High Human Development group.

Vietnam had also excellent achievements in economic reform to ensure growth and the reduction of poverty. According to the Ministry of Planning and Investment (2012), a National report indicated that the GDP per capita of Vietnam would increase 4.5 times to over 1800 USD in 2017. Vietnam has transformed to a lower middle-income country by the relatively rapid and stable growth of its economy. However, economic sustainable development has not been harmoniously combined with the other two aspects, since its quality and efficiency remain low because it has relied mainly on the export of raw natural resources and increased domestic and foreign investments.

The awareness of environmentally sustainable development has been reinforced in Vietnam. The National Report presented at the United Nations Conference listed many implementations of laws and policies which have been applied adequately and comprehensively throughout the country. There was a significant rise in the rate of urban solid waste collection, it was estimated to have increased by 20 to 80–82% in downtown areas and by 2 to 70–72% in urban areas from 2003 with 80% of hospital solid waste being collected and treated (Ministry of Planning and Investment 2012). Moreover, Vietnam has successfully established a system for clean water supply to provide for 76% of the urban population (Ministry of Planning and Investment 2012). However, despite those achievements, Vietnam remains fraught with major environmental issues and challenges: environmental pollution and degradation, depleted natural resources, biodiversity declines and climate change impacts. Based on the report of Thang (2016), the mangrove ecosystem continuously degraded from 70,000 ha in 2002 to only around 61,000 in 2009. Impacted by climate change, Vietnam has suffered annual losses from natural disasters around 1.5% GDP (Thang 2016).

Regarding Green technology, Vietnam is implementing policies such as the Cleaner Production Strategy until 2020, Project on Biofuel Development until 2015 and Vision 2025, Programme on Electricity Saving for 2006–2010, Law on Nuclear Energy in 2008, Law on the Efficient use of Energy, National Target Programme. Due to Vietnam's geography, the country has made great efforts to utilize solar energy, wind energy and bio energy for the country's sustainable development. The (Korea Environment Institute 2017) reported the targets of Vietnam renewable energy that by 2030, 60% of renewable energy would be from solar energy, 30% is from wind energy and 10% is from biomass energy which accordingly produce 12,000, 6,000, and 2,000 MW.

3 Research Question

The researcher is focusing specifically on green IT adoption in business because information technologies and business operations are the main factors concerning sustainability development. Vietnamese users, whose government has noticeably implemented initiatives related to sustainable development for several decades, have been chosen as the source of data which will be analysed prior to conclusions being drawn. It is essential to understand and clarify the significance and benefits of the research to the selected community. The significance of any research is seen in terms of its practical and theoretical applications. In regard to its practical significance, it aims to comprehensively examine the level of awareness, on the part of the selected community, of green IT factors, and the risks and advantages of green IT adoption. Additionally, the research findings expand the theoretical and empirical knowledge of sustainability and green IT development, making a contribution to the theory of the resource approach to adoption of green IT by businesses.

The question that drives this research is: *What is the awareness of green IT factors in business adoptions in Vietnam?* This research question aims to provide an understanding of both the green IT factors and the Vietnamese users' attitudes toward the adoption of green IT by businesses. Examining and analysing this question from different perspectives can clarify the different ways in which awareness programs need to be organised so that they are appropriate and take into account the cultural differences among business owners and consumers. The different green IT factors include various perspectives and studies of sustainability. And this question also basically discusses the effect of implementing these green IT factors in business operations. The green IT factors to be discussed are design, safety, manufacture and energy, recycling, efficiency, and social.

Another primary question is: *What are the advantages and disadvantages of green IT use in Vietnam?* This research question seeks to determine the positive and negative consequences of implementing green IT solutions in Vietnam. Due to its geolocation, Vietnam has some unique characteristics that require different green IT solutions. Additionally, the advantages and disadvantages of green IT usage depend on the Vietnamese culture, the local consumer habits, and the individual and communal activities. This research explores some of the major advantages of green IT in Vietnam. They are related to finance and the economy, brand and reputation, human resources and shareholders, and the environment. Obviously, green IT brings many better benefits to the environment such as reducing gas emissions, toxins. However, the research also points out the current disadvantages of green IT including the high cost of implementation and failure of application since they remain a relatively new technology.

This research is conducted to understand the significance of the adoption of green information technologies by businesses with the aim of conserving the Earth's natural resources, and being responsible for the future generations' economic, ecological and social well-being. This research anticipates discovering the Vietnamese users' knowledge of and attitudes towards green IT adoption by businesses and discussing the advantages and disadvantages of green IT solutions. This research will employ an online survey to examine the different opinions about the research topics gathered from a sample group. The survey data will be analysed, the factors will be generated from the survey results, and these will be compared with the findings from relevant extant literature.

4 Research Methods

Research methods are the strategies, processes or techniques that are used to collect data or evidence for analysis in order to discover new information or create a better understanding of a subject. Quantitative research methods are used to reaffirm an existing hypothesis or theory or find a new dimension for the same. The research method gathers numerical data that can be ranked, measured or categorised to give substance to theory, hypothesis or research question formulated by the researcher. This research method is a highly effective and efficient approach to collect opinions or information about behaviours, then conclusions can be drawn from the large group of samples. The method can help to reveal patterns or relationships, and to make generalizations. In contrast to qualitative research methods, this method is useful for finding out how many, how much, how often or to what extent, and it is easier to see the results or conclusions because the data is measurable and more structured (Neuman 2014; Mertens 1998).

Wilson (2010) defined the deductive approach as "developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis". In other words, deductivism is an approach of reasoning from the particular to the general. The approach tests the relationship or link that seems to be implied by a particular theory or specific case example, and determines whether it can be applied more general circumstances (Gulati 2009). This approach is also informally known as the "top-down" approach where the hypotheses can be derived from the propositions of the theory. The advantages of this method are that it may be able to explain causal relationships between concepts and variables, to measure concepts quantitatively and to generalize research findings to a certain extent. It is mostly used in scientific research to verify existing theories or hypotheses.

By utilizing the quantitative research method of data collection with numbers of online survey' results, the researcher uses the deductive approach in this paper along with quantitative research methods to formulate a set of hypotheses related to the attitudes of Vietnamese users towards green IT applications in business. The results and conclusions cannot be established until the analyses have been conducted. Additionally, the online survey approach is structured as deductive rather than inductive and designed from general to specific.

5 Results

The survey questionnaires were distributed to 103 participants who had some experience of green IT applications to business. The group for the study had ages ranging from 18 to over 50 and was randomly selected from major cities in Vietnam with a variety of professional background and education levels. The statistical package, SPSS, generally used for social science was applied for the analysis. The response rate is 100% of 103 questionnaires distributed to all the respondents. An almost equal number of surveys were returned by males and females: 58 respondents were male and 45 were female. Moreover, the two major groups of respondents were aged from 25 to 30 and 31 to 35 years, which accounted for 38.83% (40 respondents) and 34.95% (36 respondents) of all the respondents. These age groups are probably mature and young people with professional experience in business environment. Therefore, their responses would be reasonable and valuable for the research. Among 100 respondents, 64 had completed a Bachelor's degree as their highest level of education, which was four times more than the 16 respondents who had completed a Master's degree. Those participants contributed 81 of 103 responses, accounting for about 78%, for the research that represents a high-quality feedback in the result. The results also showed that respondents came from diverse areas of expertise with 13 areas of study. The dominant area of study was Information Technology, constituted 18.45%. Furthermore, most (78.64%) of the respondents agree that changing devices frequently will cause damage to the planet. The disagreements were much more negligible than the other side. Only 18.45% of respondents were unsure and only 2.91% disagreed.

The researcher carried out Cronbach's Alpha, Bartlett's test of sphericity, and Kaiser-Meyer-Olkin (KMO) to measure the quality of the data for analysis as shown in Table 1. Cronbach's Alpha is a coefficient of reliability or consistency, and the alpha coefficient for the three themes Awareness, Advantage, Disadvantage are respectively at 0.943, 0.940, and 0.951 which suggest that the items have relatively high internal consistency. Furthermore, the Kaiser-Meyer-Olkin (KMO) test measures sampling adequacy for each theme to ensure the data is suited for factor analysis (Stephanie 2016). The test also checks the proportion of variance among variables that might be common variance. As Stephanie (2016) explained the value, the Awareness and Advantages' KMO scores, accordingly at 0.862 and 0.868, are meritorious, and the Disadvantages' KMO score is 0.902 which is marvelous. Those KMO values interpret that the sampling is adequate to factor analysis. Regarding to Bartlett's test for sphericity, Stephanie (2014) proposed that the test checks the redundancy between variables. The test result for the result shows that the result is highly significant. The result for Awareness is X2 = 1721.618; df = 253; Sig. = 0.000, the Advantages is X2 = 1758.453; df = 276; Sig. = 0.000, and the Disadvantage is X2 = 1261.975; df = 78; Sig. = 0.000 which indicate that the themes of the scale are sufficiently correlated for factors to be found. In summary, these tests returned results which indicated that the validity of the survey is sufficient and significant. The three new factors which belong to each of the components have been generated and labelled; there are 3Rs, Environmental factors, and Green Design. Figure 4 shows the new factors generated by components with their variables and factor loadings.

The three new factors which belong to each of the components have been generated and labeled; there are Environmental factors, Organisational factors, and Economic factors. Figure 5 demonstrates the findings of the research for the advantage's of green IT adoption by Vietnamese businesses.

The three new factors which belong to each of the component have been generated and labelled as Social pressure factors and Economic pressure factors. Figure 6

Table 1 Cronbach's alpha, KMO, and Bartlett's test for reliability (prepared by the author)

Themes	Cronbach's Alpha	KMO	Bartlett's test
Awareness	0.943	0.862	1721.618; df = 253; Sig. = 0.000
Advantages	0.940	0.868	1758.453; df = 276; Sig. = 0.000
Disadvantage	0.951	0.902	1261.975; df = 78; Sig. = 0.000

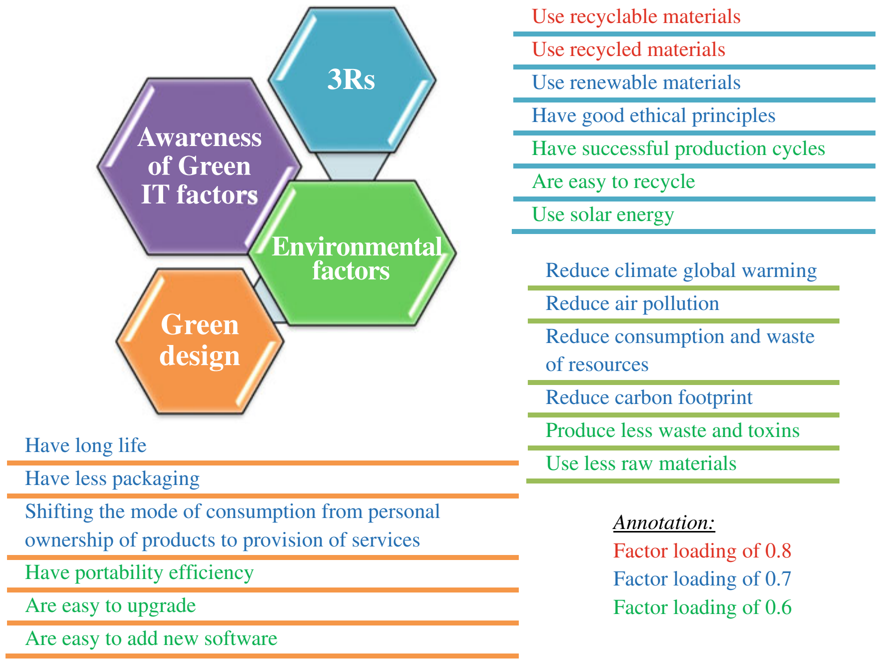

Fig. 4 Awareness of green IT factors in business (prepared by the author)

indicates the findings of the research for the disadvantages of sustainability and green IT in Vietnamese businesses

This chapter examined the data yielded by the online survey and explained the data analysis process using different techniques and tools. All the tables of demographics of the sample group involved in the survey were discussed, such as respondents' genders, areas of study, device used to connect to the Internet and how the Earth is affected by the frequent replacement of devices. As a summary from the above findings, Table 2 shows the eight new factors generated for the three themes: awareness, disadvantage, and advantage.

6 Discussion, Future Research and Limitations

The chapter summarizes the research findings and draw conclusions, thereby conforming that the research objectives have been fulfilled, and the research questions answered. Lastly, the research also suggests future research directions based on the findings, offers several recommendations, and acknowledges the limitations of the study.

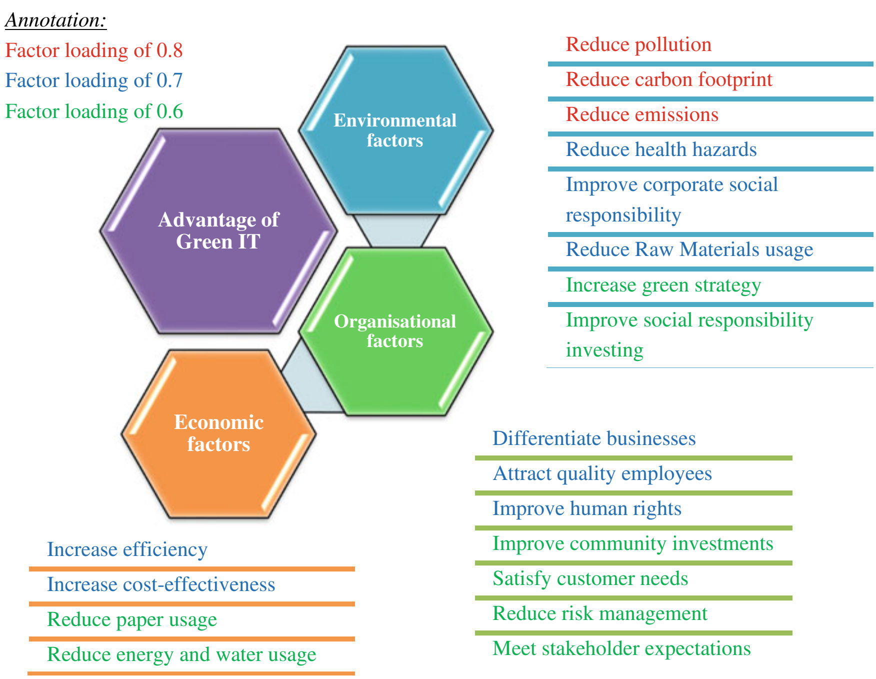

Fig. 5 Advantage of green IT in business (prepared by the author)

6.1 Discussion

According to the loading factors of awareness of sustainability and green IT in Vietnamese businesses, the variable of using less raw materials and having less waste of resources shows that they realized the threat of depletion of natural resources and the damage caused to the environment. Also, the respondents agreed that green design is a sustainable design as it reflects the responsible use of materials and energy for the benefit of today and tomorrow. On the other hand, the social aspect was missing from the respondents' data. Social aspect measures the social responsibility to improve a company's sustainability performance in four areas: community, environment, employees, governance.

For the advantages of green IT adoption by Vietnamese businesses, there are three new generated factors: environment, organisation, and economic. In developing countries, lead poisoning is the number one environmental disease among children. The results data which from Vietnamese people also showed that reducing pollution, carbon footprint, emissions, health hazards have a very high average of factor loadings above 0.8. According to the analysis results, most respondents showed that they understood the main organisational benefits of sustainability development in Vietnam. Most of them agreed that it could differentiate businesses from other businesses. The new approach of adopting and applying sustainability strategy can

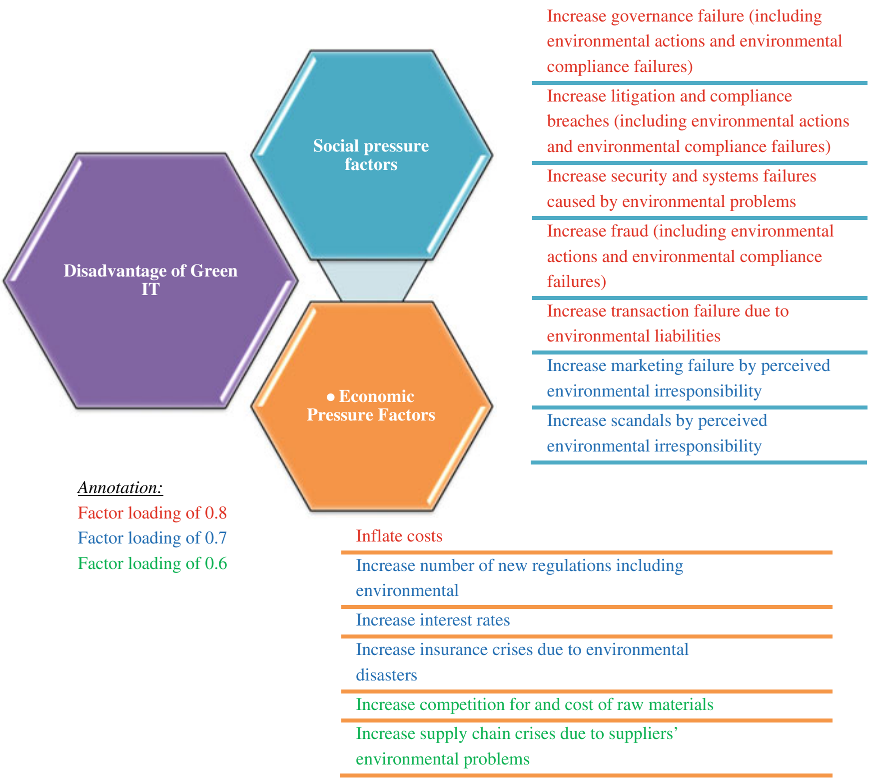

Fig. 6 Disadvantage of green IT in business (prepared by the author)

Table 2 The new factors (prepared by the author). The result for awareness is X2 = 1721.618; df = 253; Sig. = 0.000, the advantages is X2 = 1758.453; df = 276; Sig. = 0.000, and the disadvantage is X2 = 1261.975; df = 78; Sig. = 0.000

Themes	New factor
Awareness	1. 3Rs 2. Environmental factors 3. Green factors
Advantages	1. Environmental factor 2. Organisational factors 3. Economic factors
Disadvantage	1. Social pressure factors 2. Economic pressure factors

lead to many advantages for organisations, including attracting and retaining quality employees and increasing income by securing the loyalty of current customers, market share, revenue from new markets for sustainable products and services.

The literature review revealed two main disadvantages of green IT in business. They were cost and failure. A comprehensive green solution requires significant expense for installation or in the long-term when the organization grows. The aspect of failure includes finding alternatives for chemical or raw material inputs, the application of the new technology and unknown impacts on performance. The green technology approach could increase fraud, litigation and compliance failure, and governance failure in terms of environmental actions and environmental compliance. These problems have been mentioned by most of the respondents in this survey where the factor loading of "inflate costs" and "increasing new regulations" were the highest at 0.812 and 0.772 respectively. Although the green solutions will return considerably benefits in the long run, they require the involvement of many stakeholders, as well as appropriate human resources, investment, and alternative materials. Furthermore, by promoting environmental protection, every organization can become a part of the solution and not the problem. New regulations regarding the environment can be increased that would challenge the existing habits of Vietnamese people.

6.2 Future of Research

The research findings can be used as a basis for future research associated with sustainability and green IT applications in business. Most survey respondents are in Ho Chi Minh City, the biggest and busiest city in Vietnam. As that reason, research can be extended to include other cities in other states, especially in Ha Noi, the capital of Vietnam, in order to have a better understanding of the sustainability and green IT in Vietnam as a whole. Furthermore, the findings from the survey are from a developing country whose economic progress is low compared to the global average and is struggling with poverty, natural disasters, and social management that could not represent the best perspectives of the research topic in overall. The awareness of sustainability development and green IT, as well as their advantages and disadvantages, can be generalised to other countries that have different cultures and points of view. In summary, the research produced some valuable information in the area of the study, even though the results are limited by the scope of the research. It can be a foundation for other researchers in the future.

6.3 Limitations

As the research was conducted over the course of a semester, the research was able to reach only 103 respondents and there was no modification of the survey after the first few responses. Therefore, the time constraint might limit the depth of insight gained from the research due to the small number of participants and limited amount of collected data. Moreover, although the research areas of study are quite diverse, it might be considered as a low number of respondents for the reliability of the data, the findings in the research are restricted to Vietnamese people and local businesses who have applied some green IT and sustainability development. Therefore, it might provide a basis for future research on related topics using a greater range of responses. Furthermore, the survey questions and choices contained a great deal of text and unfamiliar terms which might produce a lower response rate, survey fraud or low quality of the responses. The lack of constant communication with participants to encourage them to cooperate, and to assist with their questions, might be another limitation. Lastly, there are other limitations are the absence of a trained interviewer to clarify and probe can possibly lead to less reliable data and, and sample respondents' understanding of sustainability and green IT might be limited and based only on information in the media or on the Internet.

7 Conclusion

The research aimed to provide an understanding of green IT factors and the Vietnamese users' attitudes toward the adoption of green IT by businesses. Also, it explained for the positive and negative aspects of implementing green IT solutions in Vietnam. Also, the research presented all the research findings based on the analysis of data obtained from respondents and summarized the main aspects that inform the research study. The research works revealed several new factors that were resulted in means of an analysis tool SPSS (Statistical Package for Social Science). The new factors for the awareness were 3Rs, Environmental, and Green design; the new factors for advantages were: Environmental, Organisational, and Economic; the new ones for disadvantages were: Social pressure, and Economic pressure. Moreover, the research provided some evidence to support for analysing and supporting the interpretation of the two main research questions: *What is the awareness of green IT factors in business adoptions in Vietnam?* and *What are the advantages and disadvantages of green IT use in Vietnam?* Lastly, we acknowledge several potential limitations that might restrict the generalization of the results. They are time constraints, scope of the research, and lack of guidance for participants, interviewer, and sample populations. Those limitations open opportunities for future research which can enrich the valuable findings from the research.

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