RELATIONSHIP-BASED SOFTWARE ATTRIBUTES PRIORITIZATION MODEL FOR DIGITAL LIBRARY SUSTAINABLE DEVELOPMENT TARGETS

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DEDICATION

This thesis is dedicated to my entire family members who support me along the way of this Ph.D. journey. To my husband, Mohd Shakri Yaacob, thank you for your understanding. To my parents, Haji Salleh Ahmaed and Hajjah Rokiah Haji Salleh, thank you very much for your prayer and for being the backbone of this journey. To all my kids, Nuraiman Amini, Mohd Eizlan Amili, Nuramira Emilin, and Muhammad Muhaimin Muizz, thank you for being such lovely kids. And the most thank you to Allah for giving me strength and attach me to all positive and supportive people in this challenging journey.

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ABSTRACT

Software attributes (SAs) represent the capability and usefulness of the software application in attaining sustainable development progress. To ensure a long-term positive impact on the aimed sustainable development targets (SDTs), an understanding of SAs relationship is required. The complexities of the study in this area significantly increased particularly with a huge gap in recognizing regulatory model and standards found from the literature. The previous research focusing on developing and designing new software technologies faced significant innovation and development effort gaps. Issues such as the rising cost, less strategy in purchasing as well as misallocation of the computing budget potentially lead towards lack of adopting new software technologies. Due to this phenomenon, sixty-five per cent of the countries participated in the UN2030 agenda are considered to lag in attaining their SDTs by the year 2030. This qualitative study, thus, proposed a relationship-based prioritization model in attaining the aimed SDTs for digital libraries. The focus was on deriving the SAs prioritization levels in the currently implemented software application focusing on the relationship of influences. In doing so, thirteen key attributes were generated via interviews with industry experts in this area. The pair-wise comparison and benefit-cost assessment tools were employed for data collection via structured interviews with nineteen digital libraries' stakeholders at Malaysian higher learning institutions. The finding demonstrated similarities in prioritization levels for reliability, portability, and usability of digital library software (DLS). The reliability of DLS became the priority, followed by its portability as the fourth priority and its usability was the last priority. Meanwhile, the maintainability, functionality, and efficiency of DLS were identified in different priority levels. It also demonstrated that any changes or modification on the reliability of the DLS will influence the changes to SAs at a priority level lower than it was. Furthermore, the extent to which DLS portability will or will not influence other SAs was at priority fifth. Meanwhile, the usability of DLS did not influence any other SAs in attaining the aimed SDTs. The empirical findings of this study can be used as a guide to digital libraries towards better recognition of their current capabilities of DLS in attaining their aimed SDTs. The validated relationship-based prioritization model constructed could be used as a reference to provide direction for future research, particularly, in identifying good practices and lessons learned in this area.

ABSTRAK

Atribut perisian (SA) mewakili kemampuan dan kegunaan aplikasi perisian dalam mencapai kemajuan pembangunan yang mampan. Untuk memastikan kesan positif jangka panjang pada sasaran pembangunan lestari (SDT) yang disasarkan, pemahaman mengenai hubungan SA amat diperlukan. Kerumitan kajian di lapangan ini meningkat dengan ketara terutamanya dengan jurang besar dalam mengenali kerangka dan piawaian peraturan yang terdapat dalam kajian lepas. Penyelidikan sebelumnya yang menumpukan pada pembangunan dan merancang teknologi perisian baru menghadapi jurang inovasi dan usaha pengembangan yang ketara. Isu-isu seperti kenaikan kos, pembelian yang tidak strategik dan salah pengagihan belanjawan pengkomputeran syarikat berpotensi menyebabkan kurangnya penggunaan teknologi perisian baru. Disebabkan oleh fenomena ini, enam puluh lima peratus negara yang mengambil bahagian dalam agenda UN2030 dianggap ketinggalan dalam mencapai SDT mereka pada tahun 2030. Oleh itu, kajian kualitatif ini mencadangkan model berasaskan hubungan dalam mencapai SDT yang bertujuan untuk perpustakaan digital. Fokusnya adalah untuk mendapatkan tahap keutamaan SA dalam aplikasi perisian yang sedang digunakan dengan pertimbangan mengenai hubungan pengaruh. Dengan melakukan kajian ini, tiga belas atribut utama dihasilkan melalui wawancara dengan pakar industri dalam bidang ini. Alat perbandingan pasangan dan penilaian faedah-kos digunakan untuk pengumpulan data melalui wawancara berstruktur dengan sembilan belas pihak berkepentingan perpustakaan digital di institusi pengajian tinggi Malaysia. Penemuan ini menunjukkan persamaan dalam tahap keutamaan untuk kebolehpercayaan, mudah alih dan kegunaan perisian perpustakaan digital (DLS). Kebolehpercayaan DLS menjadi keutamaan, diikuti dengan mudah alih sebagai keutamaan keempat dan kegunaannya adalah keutamaan terakhir. Sementara itu, tahap pemeliharaan, fungsi dan kecekapan DLS dikenal pasti dalam tahap keutamaan yang berbeza. Ia juga menunjukkan bahawa setiap perubahan atau pengubahsuaian pada kebolehpercayaan DLS akan mempengaruhi perubahan pada SA pada tahap keutamaan yang lebih rendah daripada sebelumnya. Kemudahalihan DLS akan atau tidak akan mempengaruhi SA lain berada pada keutamaan kelima. Sementara itu, kegunaan DLS tidak mempengaruhi SA lain dalam mencapai SDT yang disasarkan. Penemuan empirikal kajian ini dapat digunakan sebagai panduan untuk perpustakaan digital ke arah pengiktirafan yang lebih baik mengenai kemampuan DLS mereka dalam mencapai SDT yang disasarkan. Model keutamaan berdasarkan hubungan yang disahkan ini dapat digunakan sebagai rujukan untuk memberikan arahan untuk penelitian di masa depan, terutama, dalam mengenal pasti amalan dan pengajaran yang baik yang dipelajari dalam bidang ini.

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SAs	-	Software Attributes
SDTs	-	Sustainable Development Targets
SDG	-	Sustainable Development Goals
ISM	-	Interpretive Structural Modelling
SA/SDTs	-	Software Attributes and Sustainable Development Targets
UTM	-	Universiti Teknologi Malaysia
ICT	-	Information Communication Technology
DL	-	Digital Library
HLI	-	Higher Learning Institution
RbP	-	Relationship-based Prioritization

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This study investigates sustainable development targets (SDTs) with the focus on software attributes priority levels in accelerating movement towards the social, environmental, and economic sustainable concerns - (will focus on the digital library at Malaysian higher learning institutions). This introductory chapter provides a synopsis of the thesis and starts with providing an overview of the research domain in Section 1.2 together with the background of the problem in Section 1.3. The research problems and research questions are then presented in Section 1.4 and 1.5, followed by research objectives in Section 1.6 and research scope in Section 1.7. The chapter concludes with an overview of the expected contributions of the study in Section 1.8 and presents a synopsis of how the rest of the thesis is distributed in Section 1.9.

1.2 Motivation of Research

Sustainable can be defined as a development pattern in meeting nowadays essential requirements as well as future generations (Huawei, 2017; Bhatti & Danilovic, 2018; Sedlmaier, 2019). Meanwhile, the definition of being sustainable by the United Nations is about the sustainable development of society, environment, and economy. Its focus on balancing the needs of people with economy improved and natural resources are protected in the long term (Abdullah et al., 2015; Compact & Networks, 2018). Being sustainable is not a new topic being addressed worldwide. The use of the word “being sustainable or sustainability” has certainly increased in frequency, but the concept itself is hardly new (Mensah, 2019). A core of being sustainable is the relationships of all activities involved in attaining the three main

aspects: Social growth; protection of the environment; and economic stability (Caiazza, 2017; Erfurth & Bryhn, 2018; Compact & Networks, 2018).

In September 2015, the United Nations (UN) Sustainable Development Summit held in New York has approved the UN2030 Agenda (Huawei, 2017; NTNU, 2018). This summit discussed the actions of accelerating towards sustainability with 17 sustainable development goals (SDGs) and its 169 targets. All of the agenda were spanning around social, environmental, and economic development between the years 2015 until 2030. UN2030 agenda is a program for the people. It requires everyone's action to protect the planet and ensure the worldwide positive impact of people (Erfurth & Bryhn, 2018).

Figure 1.1 17 Sustainable Development Goals adopted by UN2030 Agenda (Source: UN Assembly, 2015)

As defined in the UN general assembly (Development, 2018), refer to Figure 1.1, SDG1 is to end poverty throughout the globe. SDG2 is to end hunger by improving and promoting sustainable agriculture. SDG3 is to ensure a good healthy life for all. SDG4 is about life-long learning opportunities and equal quality of education. SDG5 is about to have gender equality and empowerment especially for women, girls, and disabled people. SDG6 is to have sustainability in water management. It is included to have better infrastructure, proper monitoring budget for maintenance cost, services are improved, and full utilization of the operations. SDG7 is about to improve energy efficiency. It can be attained by minimizing energy

consumption and reducing gas emissions. SDG8 is to promote and sustain economic stability. With an increase in the productivity of employment and decent work, it is a way to attain SDG8. SDG9 is about to build and maintain a resilient infrastructure. It included the introduction of sustainable industrialization and foster innovation. SDG10 is to promote equalities between countries around the globe. SDG11 is about having sustainable cities. It can be attained via better human settlements and a safe living environment. SDG12 is about to promote the sustainable utilization of resources and production trends. SDG13 is about to overcome environmental change and mitigate its impacts. SDG14 is about actions towards the conservation of oceans, seas, and marine resources. SDG15 is to promote the approach or strategies to protect and restore sustainable use of world ecosystems. It is the need to sustainably manage the forest, control desertification, and protect land degradation. SDG16 is to promote peace and justice for the community, for example by build effective and accountable institutions at all levels. SDG17 is to strengthen collaboration and partnership worldwide for being sustainable. Within each of these goals are specific targets set to be achieved by 2030. These common goals require the participation of all including individuals as well as businesses around the world. This study used the term "sustainable development targets" (SDTs) to refer to the desire targets aimed.

Within diverse strategies and tools, the UN2030 Agenda claims that the ICT-solutions can be a key enabler to accelerate the sustainable development progress of human beings, economic productivity while natural resources are protected (Ono, Iida, & Yamazaki, 2017; IATT, 2018; J. Wu, Guo, Huang, Liu, & Xiang, 2018). ICT-solutions allow people and organizations to interact in the digital world (Ziebarth, 2019). The ICT-solutions have included all the computing peripherals, infrastructures as well as all technological innovations. It provides tools to use technology included any product or service through which information can be stored, retrieved, and manipulated. ICT-solutions are also used to handle telecommunications, media broadcast, data transmission systems as well as control and monitor a network environment (Challenges, 2015; Hinkelmann et al., 2016). It commonly acts as a comprehensive list of all computing components and digital technologies as depicts in Figure 1.2.

Figure 1.2 Components of ICT-solutions (Source: TechTarget, 2017)

(a) *Software* refers to a set of instructions that serves as the foundation for software infrastructures that link and manage hardware, networks, and other ICT components. It refers to any types of applications or programs that run on a device. Software is often developed in meeting its intended objectives by executing specific tasks (Sarker *et al.*, 2018). For example, Li and Yu (2017) discovered that freight application could improve environmental sustainability by reducing CO_2 emissions in road freight transport. Mitrovich et al. (2015) investigated how the SCADA System can positively impact environmental sustainability by enhancing the energy efficiency of the district heating system. The research on the digital library system with the radio frequency identification (RFID) system could impact the community of digital library by improving the search-and-track process in retrieving books and documents (Saleh Hassan & Talal Hussein, 2017). Commonly, software applications are an integral part of an organization's IT strategy.

(b) *Hardware* refers to the physical aspects of a computer. It includes all computing peripherals such as the mainframe, CPU, workstation, and other tangible elements. Hardware needs to be embedded with appropriate software to function as its intended purposes.

(c) *Transactions* refer to any automated digital transactions that ease the tasks within the organizations without the use of papers. Digital transactions are also referred to as the sequence of information exchange that is to satisfy the request and for ensuring database integrity. Digital transactions do not only save time and money but also enhance customers' experience and improve tracking capabilities that help reduce errors (Engin & Treleaven, 2019; Kostoska & Kocarev, 2019).

(d) *Communication technology* refers to the integration of telecommunications relevant equipment to enable users to access, store, disseminate, and manipulate information (J. Wu *et al.*, 2018). Communication technologies occur when the communication participants need to exchange information via technology, for example, over electromagnetic radiation through space such as radio or light (Agostinho *et al.*, 2016).

(e) *Data* refers to digital data that use specific machine language systems. And, these digital data can be interpreted by various technologies (Engin and Treleaven, 2019). For example, a binary system, which capable of storing complex audio, video, or text information in a series of binary characters (Ramadani, Kurnia, & Breidbach, 2018; S. M. Wu, Chen, Wu, & Lytras, 2018).

(f) *Internet access* refers to the environment in which users can connect their computing devices to the internet. They are connected at different internet speeds subject to data signal rate performance (Jin and Ji, 2018). The internet access evolution began with dial-up internet access and it is enhancing with technology changes by providing faster and reliable options. The factors that influence internet access depending on the region, internet service provider, and type of connection. It is a system of interrelated computing devices, mechanical and digital machines that allows these aspects to be connected, interacted, and exchanged data via the internet (Bashir et al., 2017; Sarker et al., 2018).

(g) *Cloud computing* refers to the practice of storing, managing, and processing data via the network of remote servers hosted on the internet instead of using

a local server (Yan, Xue, Ling, Jin, & Ren, 2017; Kern, Silva & Guldner, 2018). It shares resources from applications to data centers in achieving coherence and economies of scale which is similar to a public utility (IATT, 2018). The cloud computing term is commonly referring to the data centers that are available for users through the internet. It is capable in terms of distributing any information needs over multiple locations from central servers.

In the context of this research, according to Wu (2018), the focal point of SDGs 1, 2, 3, 8, and 9 are on economic sustainability. The goals designed with ICT-solutions as the tool is to expand economic productivity, increase food security, form connectivity in the health ecosystem, transform business endeavors, as well as build and maintain resilient infrastructure for all people. While the SDGs 4, 5, 10, 11, 16, and 17 are looking into the sustainability of social and political. For example, by offering openness, stability, and security of the social and political institutions through the capability of ICT-solutions (Mensah, 2019). SDGs 6, 7, 12, 13, 14, and 15 emphasize the significance of environmental sustainability and the need to address climate change by having smart ICT-solutions that promote biodiversity, apart from protecting forests and oceans (Compact & Networks, 2018). Indeed, the reviews performed by Ramadani et al. (2018), Erfurth & Bryhn (2018), and Saravia-Pinilla et al., (2016) concluded that ICT-solutions has a significant impact on the realization of sustainable development (Saravia-Pinilla, Daza-Beltrán & García-Acosta, 2016; Ramadani, Kurnia, & Breidbach, 2018; Erfurth & Bryhn, 2018).

Appendix A summarises the SDGs and their relations with ICT-solutions for sustainable development found in the previous studies. Furthermore, the International Telecommunication Union (ITU) which is a United Nations specialize agent for ICT-solutions on SDTs found that individuals, communities, and economies were recognized the importance of ICT-solutions in completing their intended task (Huawei, 2018). For example, the significant increase in the subscription of fixed broadband (see Figure 1.3) and individuals' internet (see Figure 1.4) (Erfurth & Bryhn, 2018).

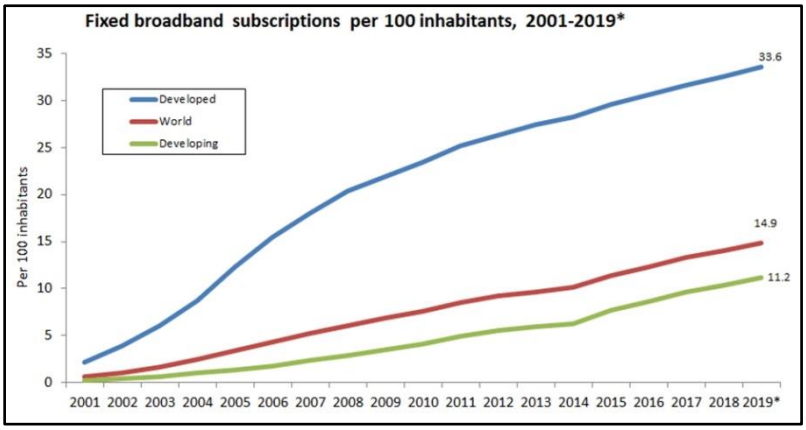

Figure 1.3 Fixed Broadband Subscription, 2001-2019 (Source: ITU, 2019)

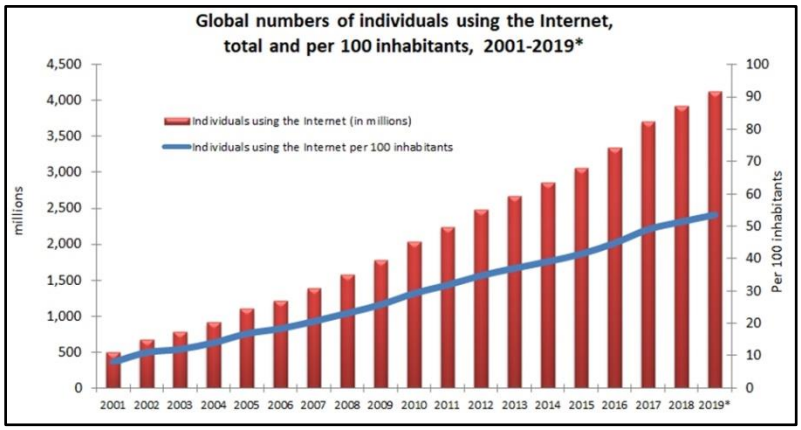

Figure 1.4 Global Internet Users, 2001-2019 (Source: ITU, 2019)

The impact of the ICT-solutions on the productivity growth, improve the quality of life of society, cannot be denied (Kostoska & Kocarev, 2019). The ICT-solutions including its infrastructure, software, hardware products, services, or tools have the potential to alter how and where people work and live (Engin & Treleaven, 2019). It plays a role in changing and improving the efficiency of an environment as well (García-Mireles et al., 2018; Ramadani et al., 2018). From food manufacturing (Selmani *et al.*, 2019) to nuclear plants, from chemical processing to biotechnology processing (IATT, 2018), ICT-solutions allow us to control and manage industrial activities such as minimize pollution, improve efficiency and protect the environment as well (Wei et al., 2017; J. Wu et al., 2018). In fact, by deploying responsibly the ICT-solutions help drive progress on the SDGs ('2019 Huawei', 2019). The capability of ICT-solutions in shifting us towards sustainable development, thus, becomes a driving force for this study to understand further on this topic.

1.3 Problem Background

Despite all great positive impact of ICT-solutions on the development of community and economy, the major world leaders recognized that being sustainable is still a major challenge that remains today (Freire, 2017; Abazi, Chaushi, & Chaushi, 2017; Penzenstadler et al., 2018; Ziebarth, 2019; Kostoska & Kocarev, 2019). It covers broad challenges that stretch from economic inclusion, diminishing natural resources, geopolitical instability, environmental degradation, and multifaceted impacts of climate change (Ziebarth, 2019).

In the context of ICT-solutions can be a key enabler to attain sustainable development. Figure 1.5 shows the problems found in the previous studies.

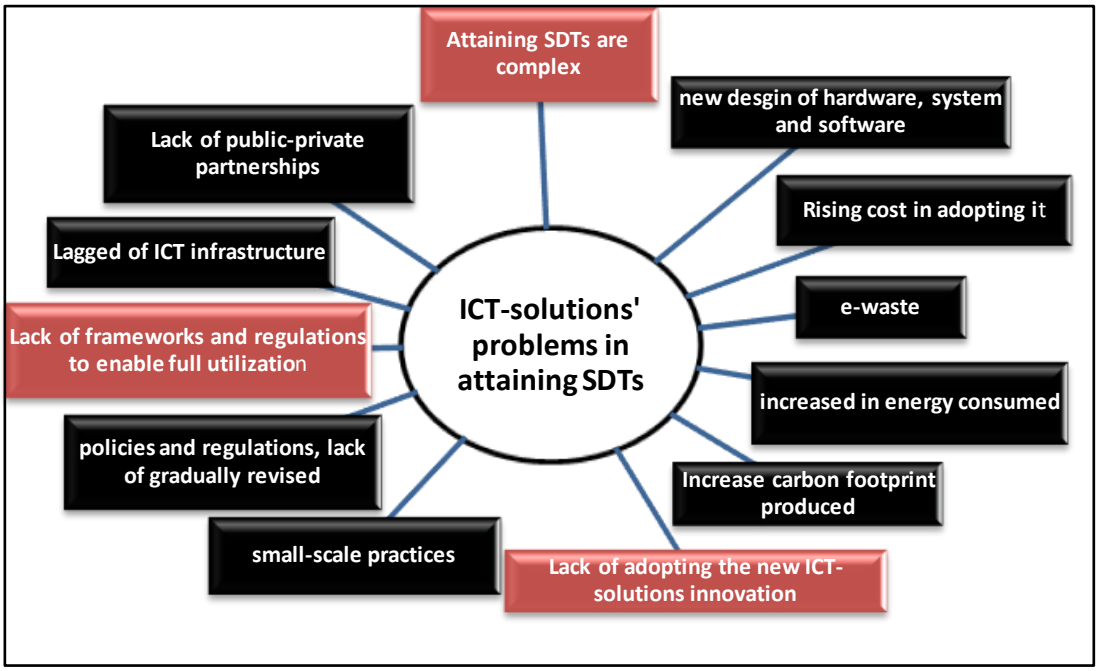

Figure 1.5 Problems of ICT-solutions in attaining SDTs

Most of the previous researches focused more on proposing and designing new hardware devices, systems, and software technologies (Machado et al., 2017; J. Wu et al., 2018; Ziebarth, 2019; Kostoska & Kocarev, 2019; Selmani et al., 2019). For example, the development and innovation of software applications (Selmani *et al.*, 2019) and communications (Wu *et al.*, 2018). The interaction of fundamental technologies includes digital wireless environment, satellite communications,

multiplexing, and machine learning also giving a great promise in quickening the realization of SDTs (Azadnia *et al.*, 2017).

Even though the adoption of these new ICT-solutions innovation provides a great positive impact on the development of community and economy it also resulted in the rising cost to the companies (Ziebarth, 2019). These new hardware devices, systems, and software technologies are potentially disadvantaged to the companies, in terms of the cost associated with adopting them. This phenomenon normally experienced by the companies in the mid-level economic development countries. They are forced to upgrade to the new ICT-solutions development to keep the business relevant (Leng *et al.*, 2018).

Apart of the cost issue, the survey conducted by Brother (2018) found there are also a few common challenges in the process of adopting these new ICT-solutions innovation. First is the purchasing process tends to be more tactically, not strategically. It refers to many companies that tend to misallocate the ICT-solutions funds to address their problems. For example, the findings showed that most of the companies were lack of thinking strategically about the bigger picture of the new design and development of ICT-solutions intended purposes (Venters *et al.*, 2018). Most of the decision-makers normally focus on a singular productivity concern rather than evaluating companies' needs as a whole. Consequently, they overspend on a single solution that only solves "part" of their problems which addressing a single issue. Second is the new design and development of ICT-solutions are still lack security consideration (Kostoska & Kocarev, 2019). And yet many companies still adopt those new ICT-solutions innovation. These companies are still believed the basic security tools are already sufficient and they are not at significant threat (Ziebarth, 2019). Consequently, companies will spend more on fixing security issues due to ICT-solutions modification after being breached is always more expensive than ensuring adequate protection ahead of time. And, finally, many companies adopt new designs and development of ICT-solutions with a lack of an adequate long-term IT infrastructure consideration (Kostoska & Kocarev, 2019). Many of them do not understand that their current infrastructure is not sufficient to keep up with the new design and development of ICT-solutions. Consequently, some new

hardware devices, systems, and software technologies are not fully utilized for their intended purposes. Updating the infrastructure is expensive and neglecting to address the issue can also lead to expensive downtime and have a significant, negative impact on productivity (Penzenstadler *et al.*, 2018). Besides that, the new design and development of ICT-solutions are also contributed to the massive negative impact on the environment. For example, the e-waste (see Figure 1.6), significantly increased in energy consumed predicted based on the energy consumed trend (see Figure 1.7) and carbon footprint produced (see Figure 1.8) (Belkhir & Elmeligi, 2018).

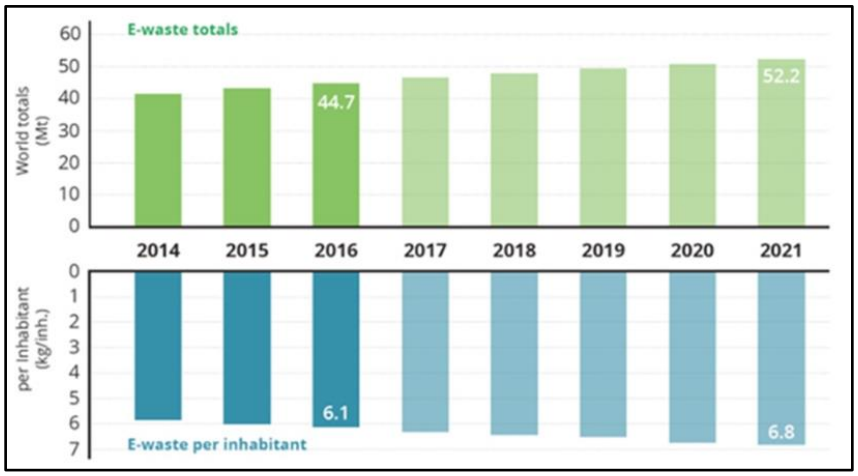

Figure 1.6 E-waste, 2014-2020 (Source: Balde, 2017)

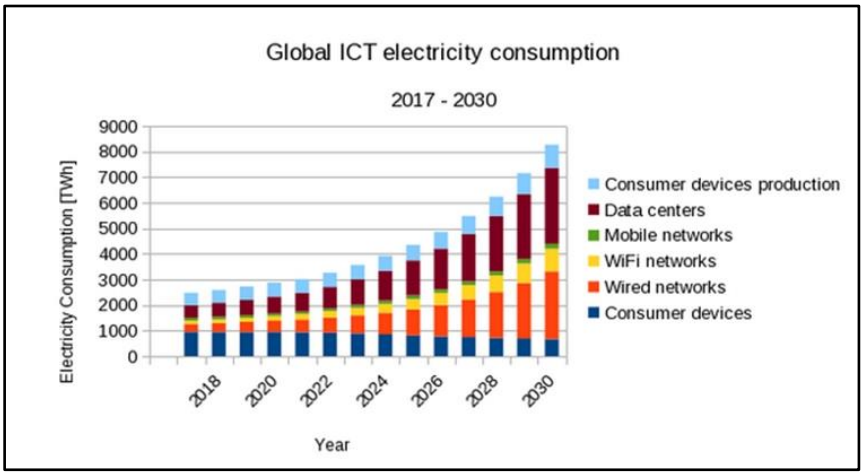

Figure 1.7 ICT Electric Consumption, 2018-2030 (Source: Huawei, 2018)

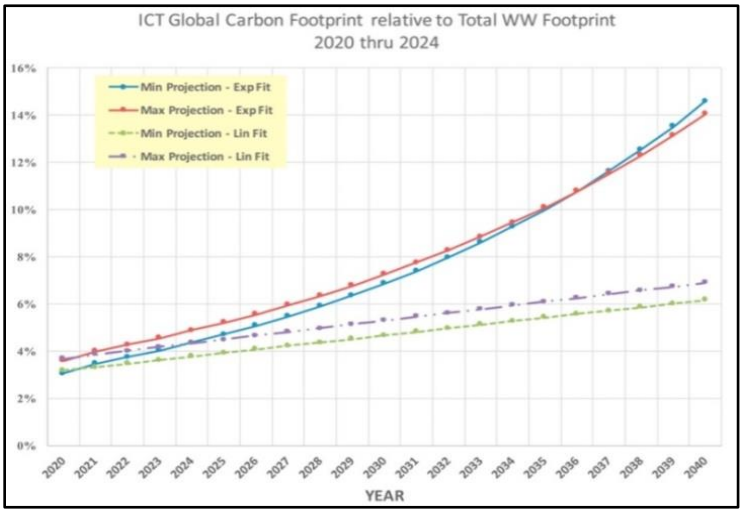

Figure 1.8 ICT Global Carbon Footprint, 2020-2040 (Source: Belkhir and Elmeligi, 2018)

Instead of some challenges faces companies in adopting the new ICT-solutions innovation, many companies are still lacking in adopting these new hardware devices, systems, and software technologies. It is supported by the study conducted by Huawei as depicts in Figure 1.9. It depicts participated countries in the UN2030 sustainable development agenda (‘2019 Huawei’, 2019). Out of fifty-five countries, sixty-five per cent of the countries are considered still lagged in attaining their sustainable development targets (SDTs) by the year 2030. They are rank and group based on their improvement in ICT-solutions and SDTs achievement. All countries were grouped into three clusters: Leaders (top performers), Contenders (mid-level performers), and Improvers (low-level performers). Leaders are the countries with scores of 75 and above (out of 100). It indicates that improvements in ICT-solutions and sustainable development are complementary. These countries with developed economies are advanced in both ICT-solutions and SDTs. They have greater resources available and currently lead the world in implementing targeted ICT-solutions in attaining their SDTs. The contenders are the countries with scores between 60 and 74 (out of 100). It indicates that these countries still lack investment, improvement, and employment in ICT-solutions towards attaining their SDTs. They represent mid-level economic development with slow-growing in ICT-solutions and their SDTs are less mature. Improvers are the countries with scores 60 and below (out of 100). It indicates the poorest performance in investment, improvement, and employment of ICT-solutions in attaining their SDTs. These countries are in the

beginning stages in terms of employing the ICT-solutions. They are still at a lower level of ICT-solutions investment and improvement focus relevant to their SDTs. Huawei concluded that the countries in the Contenders and Improvers categories which are lack of investment, improvement, and employment of ICT-solutions are lagged in SDTs achievement by 2030 (‘2019 Huawei’, 2019), including Malaysia in the Contenders group with a 66.0 score. Huawei, thus, suggested that every country should aggressively work towards any ICT-solutions relevant issues to ensure their SDTs are achievable by 2030. Although ICT-solutions does not hold all solutions in attaining SDTs, the countries in the Leaders group shows great promise for quickening the progress in attaining the SDTs via ICT-solutions (Ziebarth, 2019). Therefore, we are motivated to conduct this study to contribute to the body of knowledge relevant to ICT-solutions in the realization of SDTs in Malaysia.

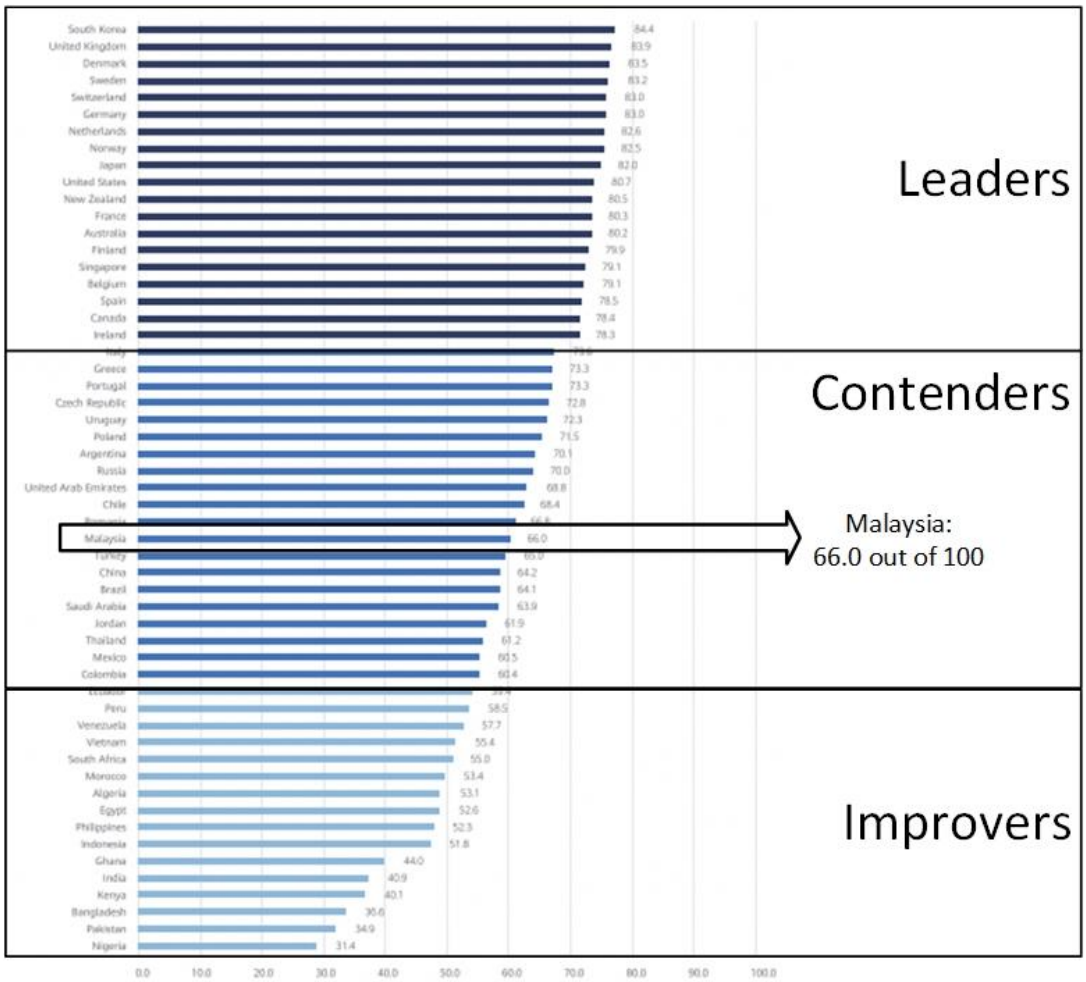

Figure 1.9 Countries’ rank for ICT-solutions development in attaining SDTs (source: Huawei, 2019)

Besides the issues faced in adopting innovation of ICT-solutions and lack of implementing the ICT-solutions, there are more issues and challenges found by the United Nation agencies. These agencies included the Earth Institute at Columbia University with the collaboration of Ericson, the International Telecommunication Union (ITU), and GSMA (Huawei, 2018).

(a) Many successful cases related to ICT-solutions in the realization of SDTs, were on a small scale of the practice. In reality, to attain sustainable throughout the globe require business models that emphasize on both urban as well as the rural area (Weib & Karastoyanova, 2016; H. K. Abdullah & Alibaba, 2017; Leng et al., 2018; Ziebarth, 2019).

(b) The policy and regulation are lack gradually revised, it is important to be gradually revised to ensure the new challenges, risks, and threats are effectively managed with the rapid ICT-solutions innovation (Hou, Li, Wang, & Zhang, 2016; Kim & Heo, 2017; Oyedeji, Seffah, & Penzenstadler, 2018).

(c) Lack of models and regulations to enable full utilization of ICT-solutions (Liu, 2018; Kostoska & Kocarev, 2019).

(d) Physical ICT infrastructures are lagged in terms of expansion and upgrading especially for public facilities such as in the education and health sectors (Jones, Wynn, Hillier, & Comfort, 2017; Ziebarth, 2019). For example, the bandwidth provided is insufficient to cope with the trend of using laptops, tablets, and smartphones to do work.

(e) Lack of public-private collaboration and partnerships that are needed to leverage the ICT-solutions (Jomo, Chowdhury, Sharma, & Platz, 2016; Penzenstadler et al., 2018).

All those listed issues and challenges found including adopting or lack of adopting the new ICT-solutions innovation become a barrier for full transformative of ICT-solutions capabilities in attaining SDTs (Erfurth & Bryhn, 2018). Thus, more studies on innovation and development efforts in seeking ICT-solutions are needed (Hák, Janoušková, & Moldan, 2016; Ziebarth, 2019), particularly in the currently

implemented ICT-solutions (Wu *et al.*, 2018). The currently implemented ICT-solutions need further researches and development in terms of understanding its capability towards achieving sustainable development (Dong et al., 2018; Kern, Silva, & Guldner, 2018). Achieving SDTs are complex (Erfurth & Bryhn, 2018; Bhatti & Danilovic, 2018; Sedlmaier, 2019). Thus, this agenda requires everyone throughout the globe to play his role (Erfurth & Bryhn, 2018; Sedlmaier, 2019).

This study, therefore, is going to fill the gap on particularly recognizing regulatory models and standards by developing a suitable model relevant in attaining SDTs; overcome the lack of adopting the new ICT-solutions by focusing on the current implemented software application. And, this study also considered the common constraints on resources, time, budget that cause attaining SDTs are complex. In the context of digital library as a non-profit institution, it is important to balance their financial management while meeting their user requirements (Suleman & Fox, 2020). It, thus concern on the important of time and cost incurred in strategizing any approach or plan towards achieving goals and objectives (Fox, 2019). Most of the previous studies in digital library software attributes prioritization relevant to sustainable development targets, focus on stakeholders' requirements prioritization rather than software attribute itself. This requirement prioritization approach leads toward the iteration of developing and modifying some of the same software attributes until all the stakeholders' requirements are meeting (Al-Badareen et al., 2011).

The software attributes prioritization was important to ensure the time spend working only on the important software attributes accordingly to their important rank levels (Maiti & Mitropoulos, 2017). The software attributes prioritization is integral because certain software attributes must be accomplished first to expedite the development process in attaining the stakeholders' requirements (Garg & Nancy, 2018). The understanding of relationships between the software attributes is necessary to identify the stability of the particular software attributes prioritized (Caiazza, 2017; Erfurth & Bryhn, 2018). Furthermore, the relationship-based software attributes prioritization is crucial to focus on the right software attributes for

the next software development and modification process to ensure the aimed SDTs achievable within the targeted time (Alidrisi, 2014).

1.4 Problem Statement

As UN2030 Agenda vision, the sustainable development progress should be achieved by the targeted year, 2030. The investment, implementation, and employment of ICT-solutions show a great promise for quickening the sustainable development progress of human beings, economic productivity while natural resources are protected. The previous researches were recognized the significant role of ICT-solutions in the realization of sustainable development (Huawei, 2018; Ouédraogo et al., 2018; S. M. Wu et al., 2018).

Unfortunately, in reality, being sustainable is still a major issue that remains today (Genanew et al., 2018; J. Wu et al., 2018; Mensah, 2019; Ziebarth, 2019). Attaining SDTs are complex (Erfurth & Bryhn, 2018; Bhatti & Danilovic, 2018; Sedlmaier, 2019). It was a call to action for everyone throughout the globe to protect the planet and guarantee the global well-being of people (Erfurth & Bryhn, 2018; Sedlmaier, 2019). The need for more contribution in finding solutions to this world's urgent challenges encourage us to investigate deeper on how to attain the positive impacts on social, economic prosperity, social inclusion and environmental protection. Thus, some of the gaps found motivate us to conduct the study towards any ICT-solutions relevant issues to help attained the aimed sustainable development targets by 2030. With the consideration of our constraints on resources, time and budget, the study focuses on filling the gap relevant with three issues. First issue is lack of models and regulations for transformative of ICT-solutions capabilities in attaining SDTs. Second issue is on the challenges in adopting new ICT-solutions innovation that potentially leads towards lack of adopting it. And, finally, the third issue is the complexity in attaining sustainable development targets.

The first issue as the United Nation agencies reported is relevant to the gap in the existing models and regulations for transformative ICT-solutions capabilities in

attaining SDTs (Liu, 2018; Kostoska & Kocarev, 2019). Without having a standard model and regulation as a guideline, not all companies capable to fully utilize their ICT-solutions (‘2019 Huawei’, 2019). Therefore, there is the need for more models and regulations to enable full utilization of ICT-solutions (Wei et al., 2017; Eizenberg & Jabareen, 2017; Hervani, Sarkis & Helms, 2017; Huawei, 2018). This study, thus, proposes a relationship-based prioritization model in attaining the aimed SDTs.

The proposed relationship-based prioritization is acted as one of the core principles that derive the structure and functionality of the entire relationship-based prioritization model. It is relationship-based due to the understanding of the core of being sustainable is that the consideration of relationship exists. And it must be prioritized due to it is possible for all software attributes that can be developed or modified all at once (Yousuf, Bokhari, & Zeyauddin, 2016; Maiti & Mitropoulos, 2017). Furthermore, with only nine more years left to attain sustainability by the year 2030, it is significantly important to prioritize the software attributes. Indeed, prioritization is the most effective method in the condition whereby some goals need to be achieved in a certain period (Bharati, 2017; Shao, Peng, Lai, & Wang, 2017).

The second issue is on the software technologies relevant issues to help in accelerating the movement towards sustainable development. Previous studies showed that designing new technologies became the main focal point in ICT-solutions, particularly in software development trends. For example, software development focuses more on the new software application (Yongqing Wang & Shi, 2017; Narendra Kumar Bhoi, 2017; Kern, Silva, & Guldner, 2018). Others are focus on the Internet-of-Things (IoT) (Belén et al., 2017; Jin & Ji, 2018; Hasegawa, 2018; S. M. Wu et al., 2018) as well as models, model, and algorithm for new software technologies innovation (Allen, Metternicht, & Wiedmann, 2016; Sarker, Deraman, & Hasan, 2018; Wu, Shen, Xu, Peng, & Ou, 2018; Liu, 2018; Kostoska & Kocarev, 2019). The application of these new software technologies was providing great help in quickening the progress in attaining the SDTs. Unfortunately; it also contributes an issue in terms of the rising cost to the companies that adopted it. As Section 1.3 mentioned, the challenges in the process of adopting these new software technologies

included less strategically in purchasing it as well as misallocate the company IT budget became another issue to the companies. All the issues relevant to new software technologies potentially lead to a lack of adopting it specifically in mid-level economic development countries. Therefore, they will be possibly lagged in SDTs achievement by 2030 ('2019 Huawei', 2019). In the context of software attributes, the disruption of the original software applications design and structure will face significant difficulty for further enhancement to take place. Fortunately, this difficulty will be minimized after determining the software attributes priority levels for the next software development and modification process. The software applications with suitable and accurate attributes, if ideally applied, can be a more important and strategic competitive advantage in today's economic scenario (Salleh & Talal, 2017). The investigation on the software attributes in the currently implemented software has significantly increased in determining the success of technical or commercial software application performance for the realization of sustainable development (Kern, Hilty, et al., 2018; Ramadani et al., 2018). It is crucial to understand the software attributes as an indicator of software application in meeting its intended task. The failure or errors in modifying the suitable and appropriate software attributes in meeting user needs have caused more than an inconvenience to users (Vijayasarathy & Butler, 2016).

In general, the currently implemented software applications can be improved by updating some existing features, enhancing for more new functionality and ease of use to meet the new requirements (Vijayasarathy & Butler, 2016). Commonly, the currently implemented software needs to be modified to meet the new user requirements. It included facilitating various functions such as managing information, manipulating data, constructing visuals, coordinating resources, calculating figures, and many more intended purposes (Khanna, 2017). It is always worthwhile ensuring that the currently implemented software applications are used up to optimum to improve the customer services, provide greater efficiency and provide the most well-targeted service improvement (Kaur & Singh, 2015; Vijayasarathy & Butler, 2016). With consideration of our limitation on the resources, such as people, time, and money, again relationship-based prioritization becomes the most appropriate model for the context of this study.

The third issue is about attaining SDTs are complex (Erfurth & Bryhn, 2018; Bhatti & Danilovic, 2018; Sedlmaier, 2019). The requirement in understanding any potential existence of relationships as well as the need for the aimed sustainable development to be achieved by 2030, increased the complexity of the study on sustainable development relevant issues (Owen Gaffney, 2014; Erfurth & Bryhn, 2018; Mensah, 2019). To ensure the long term positive impact on the sustainable development progress, thus, the "relationships" become the must consider factor in the study of sustainable development (Caiazza, 2017; Erfurth & Bryhn, 2018; Compact & Networks, 2018).

The purpose of this relationship-based prioritization model also act as a problem solving, analysis, and decision support method that works directly with stakeholders' ideas and concepts. In fact, the "relationships of the software attributes" become the must consider factor in the study to ensure the long term positive impact on the sustainable development progress (Owen Gaffney, 2014; Erfurth & Bryhn, 2018; Mensah, 2019) It, thus, significantly increased for the study of sustainable development (Caiazza, 2017; Erfurth & Bryhn, 2018; Compact & Networks, 2018). The model does propose the integration concept of relationship from Interpretive Structural Model (ISM) with relative weight. It is potentially useful for complex planning, design, or problem-solving activity. And this relationship-based prioritization model also significantly helps in understanding a complex situation involving many interrelated issues or options, to develop new insights, and to create outstanding solutions. Thus, it is significantly increased to conduct this study as part of the investigation and solutions efforts especially on how currently implemented software applications with its embedded attributes could support the sustainable development progress (Lago et al., 2016).

1.5 Research Questions

Research questions help in narrowing down the research problem to a workable size. It is used to identify issues within the problem. It also helps in generating a conceptual model for data gathering and to serve as an outline for

presenting the interpretations of the findings (Bengtsson, 2016). How organizations or companies decide to participate in attaining their SDTs can vary a great deal, depending on the region, the particular needs of the community, and the eco-system (Ono *et al.*, 2017). Motivated from the study done by Huawei specifically to explore the relationship that exists in ICT-solutions in accelerating SDGs ('2019 Huawei', 2019), thus, this research is conducted. This research focuses on understanding what software attributes prioritization levels with consideration of its relationship in supporting the interconnected elements of the environment, economy, and communities. The purpose is to balance the rapid evolution of information technology which consistently provides a high quality of human life and positive growth of the economy without damaging the environment.

With consideration of limitation on the resources, such as people, time, and money, this explorative research began with the following broad questions: "How existing software helps in attaining the aimed SDTs with consideration of its relationship of influence and with limitation on cost and time?"

When the extensive articles review was completed, the research then progressed through the thematic analysis of the data. The progression refined the initial broad questions into three specific research questions. The following research questions represent the main issues discovered and pursued by this study:

1) What are the relationship strengths of the digital library software attributes (SA) as well as its sustainable development targets (SDTs)?

2) What are the digital library software attributes (SA) prioritization levels and their relationship influences in attaining the aimed sustainable development targets (SDTs)?

3) What prioritization model that considers the relationship influences between the digital library software attributes (SA) in attaining its sustainable development targets (SDTs)?

1.6 Research Objectives

The purpose of this research is to understand the software attributes prioritization levels with consideration of its relationship in attaining SDTs. The software attributes serve as a foundational principle in both the software development and maintenance process. This research will not only inform the stakeholders and decision-makers of the features implemented by the currently implemented software but also as a guide to the researchers and application developers in understanding the issues. It also helps in determining the possible solutions in aligning with the movement towards sustainable development.

The objectives of the research are:

1) To identify the relationship strength of the digital library software attributes (SA) as well as its sustainable development targets (SDTs).
2) To identify the digital library software attributes (SA) prioritization levels and their relationship influences in attaining the aimed sustainable development targets (SDTs)
3) To develop and validate the model for digital library software attributes (SA) in attaining their sustainable development targets (SDTs).

1.7 Research Scope

Research scope refers to the coverage of the research area that will be explored and the parameters in which the study will be operating (Wester & Peters, 2000). This study is about to understand the software attributes' priority levels and the relationship between them in attaining the aimed SDTs. The proposed relationship-based prioritization model will allow identifying of the important levels of software attributes with their relationship of influence that needs to give more attention, energy, and time for software development and modification process to

attain the aimed SDTs. The scope of this study is limited to the characteristics of the investigation focus and area.

1.7.1 Investigation Focus

This study is only identifying the most relevant attributes to be investigated. In the context of this study, the attributes involved are software attributes and the aimed SDTs. Identifying the most relevant attributes is the most important phase in the prioritization process. It is to ensure the prioritization findings will contribute towards attaining long-term mission, values, and goals (Garg & Nancy, 2018; Cavalcanti, Lencastre, Fagundes, Santos, & Ferreira, 2019). Indeed, ensuring the appropriate attributes are determined will drive values to the companies. Furthermore the ability to move forward and achieved goals often depends on what had been decided to prioritize (Nagy & Abeer H, 2017). With the understanding of the importance of the attributes to be investigated, this activity is conducted until reaching saturation level (see Section 3.4.2).

The second is identifying the weight of each attribute and finally understanding the relationship between them. The stakeholders with insight and understanding about the research topic (Herterich *et al.*, 2015) will be interviewed. Their job responsibility, credibility, and specific knowledge of the issues under investigation are believable and trustworthy that will help in meeting the reliability of data gathered (Creswell, 2006). As explained in Chapter 3, the integration of interpretive structural model (ISM) and relative weight methods were employed to analyze the data collection.

1.7.2 Investigation Area

The digital libraries were chooses as the scope area of the study as it was in line with the UN2030 Agenda that reckoned the digital libraries as a platform in accessing information (Eizenberg & Jabareen, 2017). The information is significant

to promote peaceful and inclusive societies for sustainable development (Ict *et al.*, 2018). Information also provides access to justice for all and to build effective, accountable, and inclusive institutions at all levels. As SDT 16.10 quoted:

> *Ensure public access to information and protect fundamental freedoms, per national legislation and international agreements*.
>
> SDT 16.10 (Aldis & Kohrs, 2016)

And, universal literacy became the vision for the UN2030 Agenda (Chowdhury, 2014; Sedlmaier, 2019). International Federation of Library Association (IFLA) has been actively engaged with the UN2030 Agenda by advocating for the inclusion of access to information, safeguard the cultural heritage, universal literacy, and access to information technology in the sustainable dimensions model (Singh & Sharma, 2015; S. S. Chen, 2016). Indeed, in our knowledge society, digital libraries provide access and opportunity for all (Alzahrani *et al.*, 2019) and they are recognized as a key institution for achieving the SDGs (Fox, 2019).

The digital libraries are well-known in creating, storing, and transmitting information. It, thus, lead us to focuses on understanding the digital library software that supporting the interconnected elements to the environment, ecosystems, and communities. In general, the objective of digital libraries is to balance the rapid evolution of information technology with the goal of consistently provides high quality and update the information to the society and positive growth of digital libraries economy without damaging the environment. This research scope, thus, looked at the relationship of influences between digital library software attributes in attaining the SDTs. With our limitation on the resources, such as people, time, and money, the digital library with the determined characteristics will be chosen. It must have various information collection formats, services provided can be accessed via physical location or internet, implementation of the computing environment and it must have its own managerial and information technology staffs.

In fact supported by a study done by Huawei (2019), as depict in Figure 1.10, found that SDG4: Quality education which particularly in increasing access to

information and service became one of the important ways for ICT to drive sustainable development ('2019 Huawei', 2019). Indeed, ICT infrastructure, connectivity, and the availability of e-devices including mobile phones and computers contribute helped in enabling access to information and services. Thus, it potentially help formed a basis for progress on almost all SDGs in some way. As Ict et al. (2018) stated that equally access to resources and information will minimize the disparities worldwide.

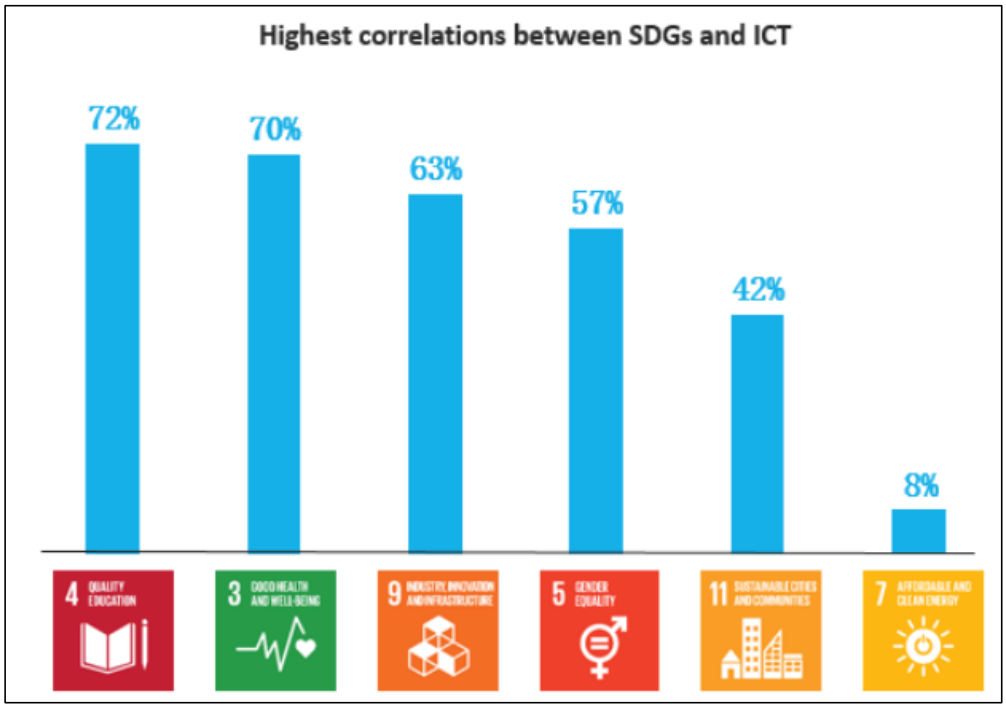

Figure 1.10 Correlations between SDGs and ICTs (Source: Huawei, 2019)

This study, thus, chooses the digital libraries at Malaysian Higher Learning Institute for the case studies as the Malaysian government is hugely integrating the SDGs into its Eleventh Malaysian Plan. The information and knowledge are expected to anchor people's growth (Department of Statistics, 2018). The main objective is to transform Malaysia into an inclusive knowledge society and unlocking knowledge resources using innovative information services (see Section 2.4.4). Thus, it increased the significance of understanding the phenomenon in the digital library area in Malaysia as a key platform for accessing the information.

1.8 Significance of the Research

The significance of this research can be categorized into two aspects including methodological and practical. In terms of methodological approach, this research involves interpretive case studies for relationship-based prioritization. It is specifically focused on the digital library at Malaysian Higher Learning Institution that can be replicated to a similar context. This could be achieved by using the applied methodology to understand the relationship-based prioritization process in a similar industry. It also can be used as a reference and analytical tool for identifying good practices, lessons learned, and emerging gaps in understanding the prioritization with relationship consideration.

In the context of a practical approach, this research offers relationship-based software attributes prioritization model to the existing requirement prioritization model. This relationship-based prioritization can help the practitioner in their decision-making by providing a better guide of how particular software attributes influence other software attributes when conducting software development or modification process. Identifying, fostering, and understanding the relationship of the software attributes that leads to the realization of SDTs is integral to the development or modification planning and policy-making of the software application. It therefore can help increase the participation of the digital library at Malaysia higher learning institutions soon.

1.9 Structure of the Thesis

The thesis is organized into seven chapters. Chapter 1, 2, and 3 are the chapters which introduce the topic of the research, discuss the related literature and planning in conducting the research. Chapter 4, 5, and 6 are the chapters that describe the empirical works conducted in this research. Chapter 7 provide the overall analysis and conclusion of the research.

Chapter 1: Introduction. This chapter introduces the research topic and discusses the issues and problems within the topic which is the Relationship-based Prioritization for Software Attributes in attaining the Sustainable Development Targets at Malaysian Higher Learning Institution with the focus on a digital library area. The chapter provides an overview of the study domain together with the background of the problem research. It then highlights the research questions and is followed by research objectives. The research scope and expected contribution in terms of practical and methodology are also explained. Finally, the chapter presents how the rest of the thesis is distributed.

Chapter 2: Literature Review. The reviews of relevant research models, and concepts related to the studied phenomenon. The chapter begins with the discussion on software application as one of the ICT-solutions. Then follow with the explanation of the existing prioritization process. The discussions of this chapter then revolve around the digital library phenomenon with the direction of the sustainable development agenda. Both two models which have been chosen to help build the theme of the digital library software attributes and its SDTs were explained. Then, the explanations on SDGs in Malaysia scenario followed. This chapter then detail out the development of the conceptual model for this research with each component explained.

Chapter 3: Research Methodology. This chapter describes the overall research design and methodology employed in the study. The chapter began with a discussion on various research paradigms and approaches employed in information system researches. This research employed the positivism paradigm. The qualitative case studies research was employed in conducting the research. This chapter also presented a discussion on how the research employed the group technique concept to minimize the individual dominant view, the interpretive structural modelling (ISM) concept to identify the relationship of influence between digital library software attributes in attaining its SDTs, the identification of digital library SA relationship strength, and how to derive the SAs relationship-based prioritization levels in attaining SDTs.

Chapter 4: Pilot Study. Experts' opinion and a pilot study were conducted with the aims of preparatory activities conducted before the large-scale study. This chapter began with how the experts' opinion was conducted to derive the key attributes of the study, namely, the digital library software attributes and sustainable development targets. Then, it was followed by the significance of conducting a pilot study. A pilot study helped in testing the planned methods, instruments, and tools that have been developed for the study. A pilot study was conducted at one of the digital libraries in Malaysia's higher learning institution. It helped decide how best to conduct large-scale research. The findings on the identification of issues and challenges by conduction a pilot study helped in refining research questions, figure out and determine what methods are best to use, troubleshooting unforeseen issues in the research, estimate how much time and resources will be necessary to complete large-scale research.

Chapter 5: Case Studies. This chapter report on the case studies conducted in four digital libraries at Malaysian higher learning institution, namely, DL-HLA for the digital library at higher learning A, DL-HLB for the digital library at higher learning B, DL-HLC for the digital library at higher learning C and DL-HLD for the digital library at higher learning D. Each case study described the context of the digital library institution studied, the identified relationships between digital library software attributes and its SDTs, their relationship strength, and their respective digital library relationship-based software attributes prioritization model in attaining the aimed SDTs.

Chapter 6: Cross-case Study. This chapter presents the findings from all four case studies reported in chapter 5. Findings are compared, contrasted, and discussed in detail.

Chapter 7: Conclusion. This chapter provides an overall concluding discussion and summarizes how each of the research questions was addressed within the thesis. It provides a summary of the study's contributions; limitations and suggestion for the further future researches that emerge from this study.

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