An Investigation into Sustainable e-Government in Saudi Arabia

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Abstract: Sustainable e-government has become an important consideration for governments. However, existing e-government literature on sustainability is sparse. A quantitative empirical study was conducted to survey the perceptions of Saudi Arabian citizens with regard to the characteristics of sustainable e-government. Survey data gathered from 442 respondents were analysed to investigate their understanding of the importance of each of these characteristics, allowing the identification of a set of key characteristics likely to influence citizens' utilization of sustainable e-government services. The study also investigated users' perceptions of three key barriers to the ability of policymakers to develop and adopt sustainable e-government systems. The results indicate that the characteristics perceived to be the most significant were usability, security, performance, transparency and flexibility, whereas respondents were relatively unconcerned with the social, environmental and economic dimensions of the impact of the software used in e-government systems. This study has also shed new light on experts' perceptions by investigating sustainable e-government features from their perspective. Data gathered from 83 respondents affirms the importance of sustainable e-government, the importance of cooperation between software development department and government agencies during designing and using sustainable e-government, and the influence of sustainability qualities on e-government. These results will be utilised in future as part of a framework for evaluating sustainable e-government.

Keywords: e-government, sustainability, sustainable e-government, software, characteristics, empirical study, end-users, experts, Saudi Arabia

1. Introduction

There is growing interest in sustainability and increasingly strong claims are made regarding sustainable development (Leyh, Rossetto and Demez, 2014). Many efforts have been taken to incorporate sustainability as a clear objective during systems development (Penzenstadler, 2014) which suggests the need for sustainability as an explicit objective within e-government development. The rationale comes from the high failure rate of these projects in developing countries arising from a combination of organisational, financial, human and infrastructure challenges. Recent studies, although limited, show that a potential solution is to see sustainability as an aspect of e-government, specifically as one of the success factor for e-government initiatives (Lessa et al., 2015;Klischewski and Lessa, 2013). Due to the limitation of studies, Lessa (2019) calls for more studies to examine the integration of sustainability and e-government (Lessa, 2019) as well as sustainable e-governance. This is a challenge due to the fact that complexity of sustainability and the lack of practical evaluated frameworks for sustainable e-government implementation, co-operation and integration hinder the efforts toward developing sustainable e-government.

E-governance and e-government are often used interchangeability in academia (Alcaide Muñoz and Rodriguez Bolivar, 2018) and are difficult to distinguish (Vasiu and Vasiu, 2006). However, while there are subtle differences between the concepts, discussion on this is outside the scope of the paper, and for the purposes of this paper e-government will be used throughout.

The most frequently cited definition of sustainability is that of the UN Commission on Economic Development in the Brundtland Report (Kates, 2010; Venters *et al.*, 2014) which states that sustainable development is *"development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs*" (Sheldrick, 2015, p.17). Sustainable e-government is defined as "*the ability of government organizations to continuously operate and use e-government systems over a long lifecycle to provide continuous benefit values for both government organizations and stakeholders*" (Nurdin, 2018;Nurdin, Stockdale and Scheepers, 2014) however, this definition is oversimplified, and generic. It ignores sustainability dimensions and future generation's needs. The study motivations for this paper are to fill the knowledge gap on sustainable e-government, and respond to the growing call in the e-government field to include, understand and

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characterise sustainability within e-government projects, and highlight the implications of sustainable e-government adoption among users in KSA context. Dzhusupova et al. (2011) state that the scoping of sustainability and e-governance is still in the early stages, while Larsson (2014) reports that sustainability has not been discussed before in relation to e-government research.

In 2005, the Kingdom of Saudi Arabia (KSA) initialised a programme of e-government services called 'Yesser', which interacts with over 170 organisations (Yesser, 2018; Alfayad and Abbott-Halpin, 2017) and whose aim is to deliver a national e-government programme (Alfayad and Abbott-Halpin, 2017). Alghazi et al. (2017) report that a national government strategy for 2030 has been launched by the KSA government for all government arms and public-sector bodies, aiming to improve performance. A digital transition plan has been launched in support of this 2030 Vision, with sustainable development a key consideration (MCIT, 2018).

E-government systems play an important role in the KSA's transformation toward good governance, providing more transparency, efficiency and effectiveness. It will involve the use of artificial intelligence and big data in risk management and in ensuring efficient and accurate decision-making. Greater awareness of the benefits of ICT sustainability, including software sustainability, would enhance Yesser. However, setting sustainability as a high-level strategic goal in ICT development would not by itself ensure sustainable solutions and could prove problematic if practical guidance is not provided.

Sustainable e-government helps to avoid e-government failure in the short and long terms (Lessa, 2019) which increases e-government longevity (Nurdin, 2013), and is reflected in cost reduction. Katz et al. (2014) state that money is not the main issue when adopting software sustainability by government projects, though other benefits could be achieved, encompassing such elements as cost reduction, facilitating maintenance, society involvement and allotting channels. It also helps to decrease bureaucracy and saves time, utilising e-government development for sustaining the economy (Stoiciu and Popa, 2012), and enhancing maintainability of e-government hardware and software to keep up with upgrades to avoid failures, as well as optimising resources in terms of hardware and software and equity (Kumar and Best, 2006), and achieving good governance such as cooperation, coordination, sharing responsibility, involvement and partnership (Nurdin, 2013). Thus, implementing a sustainable e-government system can bring more benefits for internal and external stakeholders. With this background, this study seeks to respond to the following three questions, with the purpose of exploring the relationship between sustainability and e-government with respect to users and expert:

RQ1. What are the characteristics of sustainable e-government and to what extent are they important?

RQ2. What are the barriers to adopting sustainable e-government?

RQ3. To what extent do the current sustainable e-government aspects influence developing an e-government system?

The paper structure starts with an introduction in Section 1, then has a review of literature regarding characteristics and the current situation of e-government sustainability in developing countries in Section 2; next, the research methodology is introduced in Section 3; then, the research findings and discussion are presented in section 4 and Section 5 respectively. Section 6 concludes the paper.

2. Literature review

2.1 Importance of sustainability within e-government

Pade, Mallinson and Sewry (2009) assert that the vast majority of sustainability research focuses on financial sustainability and the cost recovery of projects, while the concept is broader than that, covering other aspects such as political acceptance, and social, cultural and technological sustainability. Mursu (2002) explains the relationship between development and sustainability by noting that development which depends on modern IT cannot be achieved unless new computerised systems are sustainable and free of negative implications for the environment. Since software is a component of ICT, it contributes to the success or failure of ICT. Sustainability failure is counted as one of the three categories of ICT failure in developing countries (Gichoya, 2005). As a result, whenever the failure rate of sustainability increases, the software and ICT failure rates rise. According to United Nations Department of Economic and Social Affair (2016, p.130) *"The SDGs provide a framework to orient efforts to advance e-government and keep them focused on the overarching objective to profoundly improve the lives of all people and improve our world for the better."* E-government is a way to improve national development (Khamis and van der Weide, 2017)promoting integrated services, considering economic, social and

environmental dimensions of sustainable development and supporting integration across these dimensions (Alcaide Muñoz and Rodriguez Bolivar, 2018).

2.2 Characteristics of sustainable e-government

Calero and Piattini (2015) state that risk, security and safety are strongly related to sustainability. Moreover, Dečman (2003) affirms that without user trust, e-government systems can become unsustainable. Abu-Shanab and Al-Quraan (2015) studied the factors that influence e-government project continuity, asserting the importance of complying with national plans, goals and objectives for sustainable development. Their findings indicate that availability, participation and awareness are predictors of sustainability, whereas trust is not. Moreover, they affirm that citizens' participation makes a major contribution to e-government sustainability. Contrary to these findings, trust is generally considered an important candidate characteristic of sustainable e-government.

Razavian, Procaccianti and Tamburri (2014) state that to be sustainable, government e-services must address the economic, social, environmental and technical dimensions. Koziolek (2011) argues that system sustainability cannot be achieved unless the system is cost-efficient, maintained and supports evolution over its lifecycle. Ashaye (2014) empirically studied e-government evaluation and implementation in developing countries, identifying sustainability and transparency as important criteria during implementation.

To achieve sustainable e-government, several models and frameworks have been proposed in literature such as Quality Framework of Sustainable e- Government Development (Chutimaskul, Funilkul and Chongsuphajaisiddhi, 2008) and Sustiainability Framework for e-Government Success (Lessa *et al.*, 2015). Other models consider the wider perspective by proposing sustainable e-governance (Dzhusupova et al., 2011; Estevez and Janowski, 2013; Larsson, 2014), whereas other models propose economic sustainability as one of the evaluation aspects for e-government policies (Stanimirovic and Vintar, 2013); however, the author has not specified the exact meaning of sustainability in terms of evaluation, and social dimension indicators are ignored. Razavian, Procaccianti and Tamburri (2014) propose a model for sustaining e-services which covers four dimensions; however it lacks a way to resolve a trade-off, clear guidance, metrics and support.

All these models suffer from common issues including a narrow understanding of sustainability, which leads to dimensions such as social being overloooked, a lack of guidelines or documentation for implementation, discarding of negative impacts, lack of clear metric characteristics, lack of consdieration for identification of stakeholders or trade-off mechanisms.

2.3 Sustainable e-government in developing countries

There are several reasons for using KSA as a case study for this research. Since it is a developing country (Saxena, 2018), Sæbø (2012) makes a connection between e-government and improved sustainability, asserting that introducing e-government in developing countries impacts sustainability in those countries. Furuholt and Wahid (2008) argue that in developing countries, e-government research tends to focus narrowly on the success or failure of system development, with little research into sustainability within e-government systems, affirming little research into e-government sustainability exists. Lessa et al. (2015) report that many e-government projects become unsustainable, indicating their failure to meet stakeholders' aspirations and needs. Moreover, a qualitative study by Mkude and Wimmer (2015) comparing e-government design and implementation in developing and developed countries found that all respondents considered sustainability an important and significant factor which must be addressed appropriately. Dzhusupova et al. (2011) note that few studies have addressed the challenges which face developing countries and influence sustainable e-governance initiatives, in both identification and mitigation.

3. Methodology

This study represents the first large-scale quantitative survey in the KSA on e-government sustainability. Groher and Weinreich (2017) warn of a lack of understanding of how professionals in the software industry consider sustainability within software development projects; therefore, the study also identifies how sustainability is integrated with e-government and its influence on e-government projects. This empirical investigation is exploratory and forms part of a larger ongoing PhD study aimed at the development of an e-government framework for sustainable development.

Surveys were used for data collection; therefore, two different questionnaires were developed and distributed, namely users' and experts' surveys. Questionnaires were based on spotting gaps in literature and formulating questions to determine users' and experts' responses. The users' questionnaire was split into four main sections: namely software sustainability section which tests dimensions and their ranking, users' beliefs, intention, attitudes and perceptions regards sustainable software; sustainable e-government characteristics; barriers for adopting sustainable software and sustainable e-government; ranking of technical dimension characteristics and finally ranking of sustainable e-government characteristics. The experts' questionnaire was split into nine sections: namely policy and management systems; software sustainability dimensions; relationship between software quality and sustainability; software sustainability impact and influencing factors; ranking of technical dimension characteristics; sustainability and project management; software sustainability barriers; enterprise architecture framework; sustainable e-government aspects. In this article, a subset of both surveys is reported due to space constraints. Respondents to the users' survey were asked to evaluate the characteristics of sustainable e-government discussed in Section 2.2 and prioritised evaluating barriers to adopting sustainable e-government, whereas respondents to the experts' survey were asked to evaluate sustainable e-government aspects.

Surveys were distributed in KSA context by choosing the Ministry of Justice (MoJ) as a case for an expert survey and its private arms due to MoJ has big project, called *Najiz which is part of Yesser,* for developing e-government services within MOJ e.g. e-notarization system. Users are investigated since they are a main stakeholder for sustainability and e-government systems. Both questionnaires are self-administered avoiding bias such as interview bias; however, the distribution method was different. Users received an online questionnaire using Survey Monkey, and expert questionnaires were distributed as hard copy with human assistance for distribution and collection within the MoJ and the private sector due to individual email address not being available. Both questionnaires were distributed in Arabic and English languages in order to engage with residents 'users' or employees that do not speak Arabic, prefer responding in English or where their mother tongue is English.

The majority of the 88 items in the users' survey[1] and 151 items in the experts' survey[2] were of the closed type. Participants were asked to evaluate their level of agreement or disagreement for each item on a five-point Likert starts with 1=strongly disagree and ends with 5=strongly agree. Ranking questions were adopted for three questions in users' survey and two questions in experts' survey. Some open questions were also included, to explore respondents' opinions beyond the limits of fixed responses. However, the scope of this paper is limited to the analysis of a subset of the results for both surveys.

The reliability and internal consistency of the both surveys were assured by two methods: experts (ten for the expert's survey and Four for the users' survey) from different field and knowledge levels were asked to assess its face validity and the Cronbach's alpha internal consistency test was applied. Alpha values for the users' survey ranged between .828 for the three items on barriers to adopting sustainable e-government systems and .874 for the nine items on sustainable e-government systems. The expert survey Alpha values for this scale, discussed in 4, is .583. These are well above the 0.5 cut off value below which Cronbach (1951), Helmstater (1964) (as cited by Bowling and Ebrahim, 2005) and Nunnally (1978, as cited by Field, 2013) suggest that consistency is problematic.

Ghazi et al. (2017) report that translation is the usual issue for globally conducted questionnaires; therefore, since both surveys were provided in English and Arabic to engage with KSA residents or employees of other nationalities who may speak just English, translations were proofread by linguistic professionals. For clarity, in the users' survey, a definition of sustainability, based on the UN Brundtland Report was introduced over each item and on each page; green software, open source software whereas sustainability definition only provided in experts' survey. An e-government sustainability definition was deliberately omitted for both surveys to extract the participants knowledge i.e. understand population (Wohlin et al., 2012) without influencing their understanding.

3.1 Data collection and Analysis

Data collection for the users' survey started in December 2017 whereas the experts' survey was in Oct 2018. SPSS was utilised for data analysis and descriptive statistics including mean and frequencies, non-parametric

[1] https://bit.ly/2ITYncg

[2] https://bit.ly/2nuajSc

Friedman, Spearman's, a Mann-Whitney U test, Kruskal-Wallis test and Cronbach's alpha coefficient tests were utilised. Friedman is used for analysing ranking as nonparametric equivalent of a one-factor repeated measures ANOVA (Hinton et al., 2004). Spearman's was used to assess the strength of the relationship between two variables (Saunders, Lewis and Thornhill, 2009) which is an alternative to Pearson correlation; however, the use of the former was due to one of the independent variables not being normally distributed (Hinton et al., 2004). A Mann-Whitney U and Kruskal-Wallis test was used to test and investigate the difference between groups, where the former is an alternative to the unpaired t-test and the latter is an alternative for the one-way ANOVA. The previous tests were used because the assumptions for a normal distribution test are uncertain. Cronbach's alpha coefficient was used to test reliability and internal consistency of questionnaires.

Non-probabilistic sampling was adopted in the data collection phase, because these are beneficial characteristics of exploratory research, particularly when seeking to understand a new situation (Cummings and Sibona, 2017). Since the study is oriented to a particular case context, claiming random sampling for the whole universe can be impossible; however, random sampling can be achieved for merely the target sample for a study context. Multiple sampling strategies were used, in order to improve the quality and quantity of the responses. Regarding users' questionnaires, there were 442 responses in total, but no response rate could be calculated because the questionnaire was deployed online, using snowball, convenience and volunteer sampling utilising email lists related to the author and social media, such as Twitter, Facebook and WhatsApp groups oriented to KSA citizens in Arabic language only. For example, WhatsApp Saudi programmers groups, Telegram Saudi researchers groups such as Data science, AI, software modelling and others field such as social science and medicine, employees groups within Saudi sectors (public and private) were all utilised and Twitter accounts for Arabic Saudis were tweeted with the link of the study, asking only people in KSA for responses. An email list was also used. However, in all social media utilised, a combined message explained the reason for the study and why it was being conducted, and how to answer was explained. As indicated by Cummings and Sibona (2017), the popularity of social networking sites (SNSs) is increasing among the research community for recruiting survey participants. Since only a subset of the results are explored in this paper.

Exploratory Factor Analysis (EFA) was conducted to explore the dataset, reduce complexity in dataset to identify latent factors and find meaningful interpretation. Preliminary tests such as KMO and Bartlett's Test showed greater suitability for EFA since the KMO index is over the minimum value for a good factor analysis (Pallant, 2011). Twelve questions in the users' questionnaire relating to sustainable e-government characteristics and barriers were analysed. The analysis[3] of EFA yielded three factors where factor 1 and factor 3 are cross-loaded in seven items for the same construct, therefore retaining one factor needs to be conducted based on accurate method robustness across alternatives for these other decisions. Parallel Analysis (PA) is one of the most accurate methods to determine the number of retaining factors (Hayton *et al.*, 2004) excluding factors due to chance (Wood, Akloubou Gnonhosou and Bowling, 2015). PA is conducted based on O'connor's (2000) programme and the results show two factors retained from PCA which have a higher Eigenvalue than PA factor 1 and factor 2, whereas factor 3 has a lower Eigenvalue; therefore, factor 3 could be due to chance and it was not retained. PCA was repeated with a fixed number of factors, equal to two as suggested by PA and the result shows the validity, reliability and unidimensionality of these two constructs namely sustainable e-government characteristics and barriers. Ranking questions are excluded to be tested for EFA since it is based on an Ipsative measure (van Eijnatten, van der Ark and Holloway, 2015) which produces biased results for factor analysis (Hino and Imai, 2019).

The distributed copy was by hard copy for expert survey; the response rate was 62%. Non-probabilistic sampling was utilised by using convenience sampling. There were 83 responses to the expert survey, with support from Ministry of Justice (IT dept.) and its arms from the private sector in distributing and answering this survey. EFA has not been conducted since the sample size is less than 150 observations (Swanson and Holton, 2005).

4. Findings

In this section, findings are presented for both surveys followed by discussion. Users' response are presented firstly, which answers research question 1 & 2 followed by the experts' response which answers research question 3.

[3] https://bit.ly/2IGAc9I

4.1 Demographics

Demographics questions were asked to assess basic demographic information, and to determine whether results were affected by the way that respondents answered questions dependent on age or income, etc. the demographic questions asked in the two questionnaires differed, due to the nature of the questionnaires, such as job role. The key finding for the independent variables for the users' questionnaire can be seen in Table 1 whereas the experts' questionnaire can be seen in Table 2 .

Table 1: User's questionnaire independent variables

Variable	Classification	N	Variable	Type	N
Nationality	Saudi	407	Gender	Male	342
	Other	35		Female	100
Age	Less than 20	12	Qualification	Below or high school	27
	20-30	134		Diploma	35
	31-40	202		Bachelor	204
	41-50	73		Higher degree	176
	Over 50	21			
Experience	1-2	51	Income	Under2000	37
	3-5	55		2000-5000	36
	6-10	80		6000-9000	62
	Over 10 years	187		Over 9000	230
	No experience	69		I would rather not say	77

The demographic information for users' questionnaires showed 92% were Saudis and 77% were male, which shows the results can be semi-biased to male due to the nature of the distribution method (online) and participation strategy (voluntary). The average age is 20-40 years and 85% were qualified with a degree and have job experience. The Spearman's rank-order correlation coefficient (r_s) was calculated to determine relationship between gender, job experience and income, which showed a statistically positive correlation between gender and experience where $r_s = .100$ *and* $p = .035$. The result showed females have higher job experience than males. There was a statistically significant negative correlation between gender and income where $r_s = -.157$ *and* $p = .001$ which showed that males have higher income than females. Another point of interest is that there was a statistically significant positive correlation between qualification and job experience where $r_s = -.159$ *and* $p = .001$, which showed when the respondents have higher qualifications they have less job experience.

Table 2: Expert's questionnaire independent variables

Variable	Classification	N
Nationality	Saudi	27
	Other	56
Age	20-30	32
	31-40	39
	41-50	11
	Over 50	1
Experience	Less than a year	8
	1-2	5
	3-5	14
	6-10	32
	Over 10 years	24
Qualification	Diploma or below	7
	Bachelor	62
	Higher degree	14

The expert questionnaire demographic information showed that 67% were non-Saudi, which shows a sample diversity which could be beneficial in terms of adding experience to work and support organisation capability. This is proven by Spearman's rank-order correlation coefficient (r_s) which showed a statistically positive correlation between nationality and job experience, i.e. when the nationality is non-Saudi, the years of job experience were higher where $r_s = .218$ *and* $p = .048$. Moreover, 67% of the respondents had gained more than six years' job experience and 91% have a degree qualification. 85% were aged between 20 and 40 years.

4.2 Research question 1

In order to answer the first question, Figure 1 ranks the results for nine questions on sustainable e-government systems. The results are shown as means in rank order for brevity.

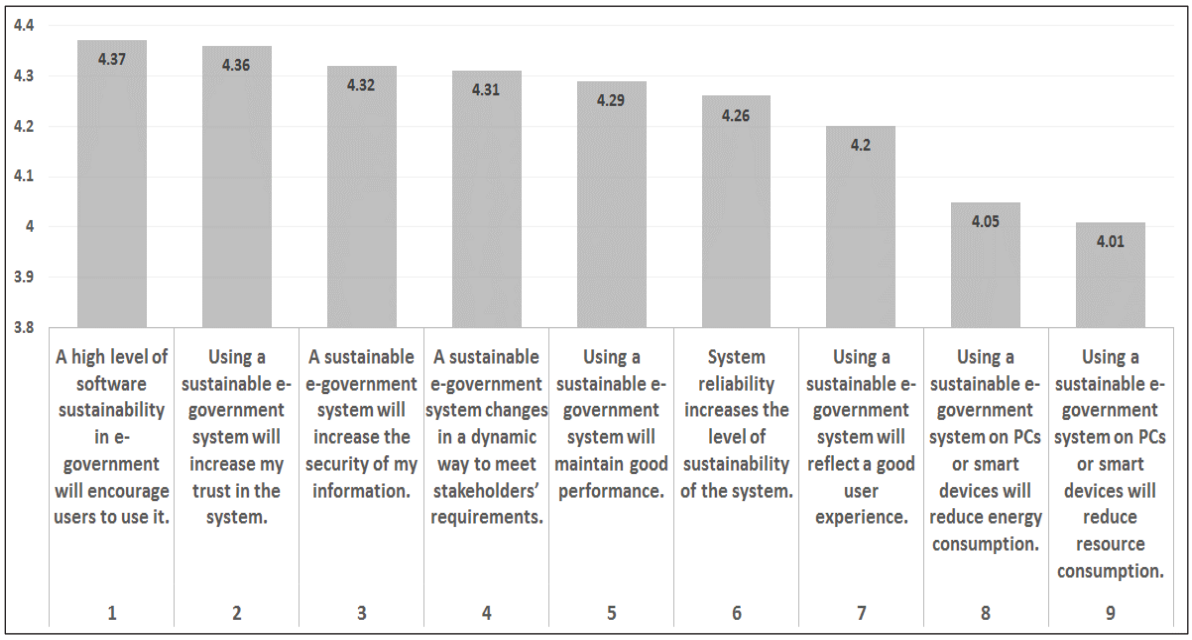

Figure 1: Sustainable e-government characteristics

Responses showed a positive relationship between the level of sustainability within an e-government system, especially its software, and its adoption. Trust and security were found to be respectively the second and third most important characteristics of sustainable e-government systems. This is consistent with Choi et al. (2014), who found that security and privacy must be considered in order to achieve a sustainable e-government system.

An exploratory study by Condori-Fernandez and Lago (2017) identified satisfaction in terms of trust as a very important requirement for social sustainability in software-intensive systems. Similarly, Almarabeh and AbuAli (2010) state that trust is an important factor affecting the success of e-government systems. However, our results contradict those of another recent exploratory study, by Abu-Shanab and Al-Quraan (2015), who concluded that while the perception of trust is an initial factor attracting people to use a system, it does not contribute to the sustainability of e-government projects by making them more likely to continue to use it. They nevertheless argue that trust is a social belief which could evolve in future. Unlike the findings by Abdelhafez and Amer (2014) which show Saudi users need to be aware of trust, security and privacy, our result conflicts with these findings as showing high levels of awareness among users. A Kruskal-Wallis test showed that there was a statistically significant difference in interest in trust and security among users' qualifications, as seen in Figure 1, where trust was reported as $\chi^2(3)=8.519$, $p=0.036$ and security as $\chi^2(3)=9.183$, $p=0.027$. The mean rank for trust among users' qualifications (Below or high school, Diploma, Bachelor and Higher degree) is (164.9, 247.6, 225.3 and 220.5) and for security is (186.5, 265.5, 226.8 and 211.8) respectively. The result shows users who holds diploma qualification pay higher attention to trust and security more than other qualifications which shows a good level of awareness among users, even if the qualification is lower than an undergraduate or postgraduate degree. Lessa et al. (2015) report that many e-government systems become unsustainable because they fail to satisfy stakeholders' needs (explored in question ranked 4; see Figure 1). In view of the importance of meeting stakeholders' requirements, which can evolve over a system's lifespan, system flexibility is an important characteristic of sustainable e-government. The fifth most important characteristic of sustainable e-government, according to the current survey, is performance. Rodrigues, Sarabdeen and Balasubramanian (2016) found that the adoption of e-government increased when the performance expectancy of e-government services was high.

The sixth most important characteristic was reliability, indicating a positive relationship with the level of sustainability within e-government systems. Usability was ranked seventh, indicating less importance compared to other studies, such as that of Venkatesh, Chan and Thong (2012), who found usability to be a significant factor

in determining citizens' intention to use services and be satisfied by them. Similarly, Condori-Fernandez and Lago (2017) identify usability as an important aspect of social sustainability in software engineering development. A review of other studies by Rodrigues, Sarabdeen and Balasubramanian (2016) also found that usability was a key factor in effective e-government systems. Our results are consistent with the literature in finding that the use of sustainable e-government systems will reflect a better user experience.

The two characteristics which received the lowest scores concerned the environmental dimension of sustainability, specifically the beneficial effects of sustainable e-government on the consumption of energy and of resources. It is notable that relatively few respondents agreed strongly with either of these two items, compared with those ranked more highly. This could be interpreted as revealing a degree of uncertainty and lack of understanding of the environmental dimension and its characteristics, or of the whole concept of sustainable e-government. A relatively high proportion (around a fifth) of respondents gave neutral responses to these two items, showing that environmental issues are not clearly understood by KSA citizens. Venkatesh, Chan and Thong (2012) affirm that computer resource requirements have an important effect on citizens' intention to use services and their satisfaction with them. The lack of concern with the consumption of both resources and energy in the present study places the environmental dimension as the least important in software sustainability in the KSA. Further investigation is needed into green software issues, their intertwining with the sustainability of e-government and how members of society understand these concepts.

A study by Aljarallah and Lock (2018c) investigated the difference between green-ability and sustainability. Unsurprisingly, around 40% of respondents expressed no opinion about similarities and differences between these concepts and a similar number had an incorrect understanding of the difference. While the overall results show that using sustainable e-government systems can reduce energy consumption on smart devices and PCs, this appears to be of little interest from the perspective of users in the KSA.

The Spearman's rank-order correlation coefficient (r_s) was calculated to determine the relationship between the importance of sustainability characteristics and the length of respondents' experience with e-government services (less than a year, 1-3 years, 4-6 years, over six years). The use of r_s was appropriate because the results were not normally distributed. We found a strong, positive correlation between experience of e-government use and seven of the nine characteristics explored in Figure 1, all statistically significant according to their r_s and *p*-values, as seen in Table 3.

Table 3: Spearman's rank-order correlation results for experience in using e-government and sustainable e-government characteristics

Sustainable e-government characteristics	r_s	*P*
Trust	.152	.001
Performance	.119	.012
Resource consumption	.118	.013
Usability	.163	.001
Flexibility (Changing needs)	.111	.020
Sustainability increases adoption	.106	.026
Reliability	.175	.000

The results in Table 3 show that trust, usability and reliability were the most strongly correlated with e-government experience. Two characteristics, namely energy consumption and security, are absent from Table 3 because they were not significantly correlated with experience of e-government use.

Spearman's r_s was also calculated to determine the relationship between each sustainable e-government characteristic and the strength of respondents' knowledge of sustainability (none, poor, moderate, good, very good). There was a strong, positive and statistically significant correlation between sustainability knowledge and five characteristics, according to their r_s and *p*-values (Table 4).

Table 4: Spearman's rank-order correlation results for sustainability knowledge and sustainable e-government characteristics

Sustainable e-government characteristics	r_s	*p*
Trust	.171	.000
Performance	.138	.004
Resource consumption	.117	.014
Usability	.211	.000
Reliability	.129	.007

Table 4 shows that the characteristics most strongly correlated with e-government experience were trust, performance, usability and reliability. Overall, the results confirm the importance of awareness of the sustainability concept and its relation with e-government.

4.2.1 Ranking

Overall mean values were calculated and a non-parametric Friedman test was conducted, allowing the characteristics to be ranked by total mean scores as shown in Figure 2.

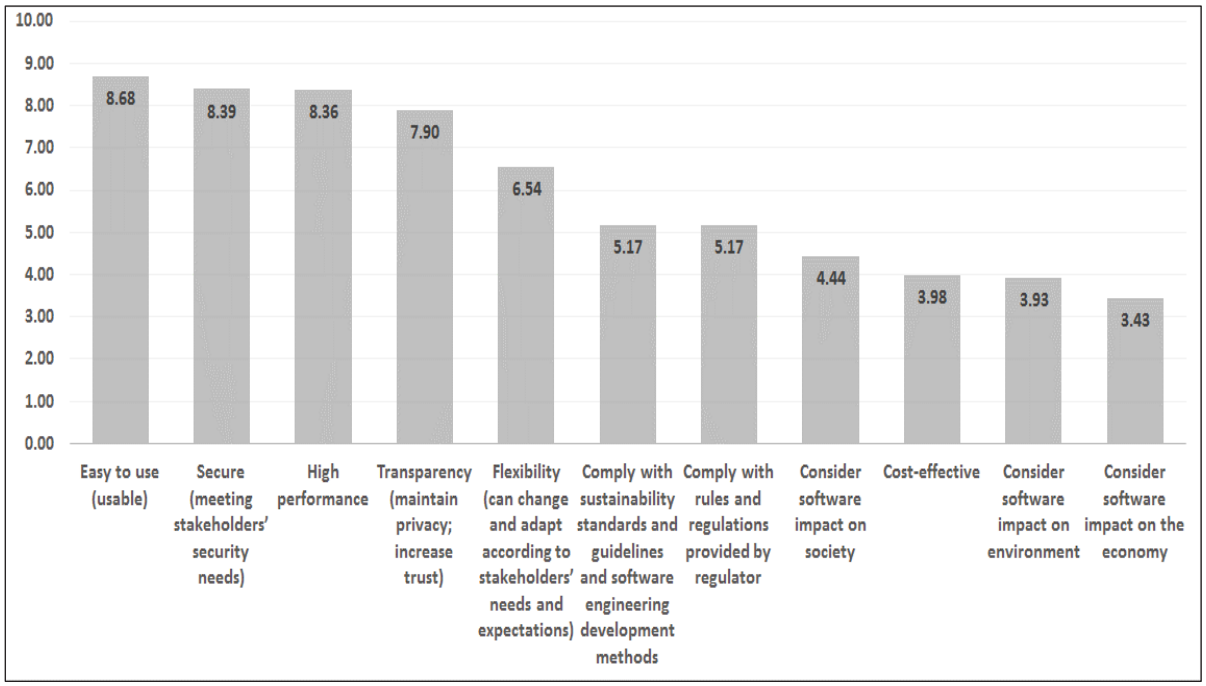

Figure 2: Total mean scores for sustainable e-government characteristics

Figure 2 shows that participants considered usability more important than users' security, contradicting the results reported earlier. The contradiction can be justified as the previous question asked respondents how important a specific characteristic is for sustainable e-government, whereas in this question, respondents rank a characteristics against one another. Abdelhafez and Amer (2014) indicate the complexity of the e-government system for Saudi users due to the system design, as information and services are linked together in the portal. Other highly significant characteristics were performance, transparency and flexibility, while sustainability standards and compliance with software engineering guidelines during the development of e-government systems were more important for respondents than compliance with conditions established by regulators, which indicates users' awareness of sustainable e-government. It is notable that respondents were not greatly concerned with the impact of sustainable e-government software on social, environmental and economic factors but that they were somewhat more concerned about its social impact.

Finally, the study identified gender differences in the responses. According to the results of a Mann-Whitney U test, males ranked usability and flexibility higher than females did to a statistically significant degree: U = 13702, p = .002 and U = 12955, p = .000 respectively. Conversely, females ranked software impact on society and cost-effectiveness statistically significantly higher than males: U = 13918, p = .004 and U = 13544, p = .001 respectively. The mean rankings of these characteristics also differed by gender in that the first priority for males

was usability, whereas for females it was security. Usability has greater influence in sustainability literature than security does (Aljarallah and Lock, 2019a). Differences between genders for e-government software requirements can be critical to e-government social sustainability, i.e. equity. A Kruskal-Wallis test conducted shows there was a statistically significant difference in flexibility and complying with sustainability standards, guidelines and SE development methods among users' job experience as follows: flexibility $\chi^2(4)=15.079$, $p=0.05$, complying with sustainability standards and guidelines and SE development methods $\chi^2(4)=11.996$, $p=0.017$. The mean rank for flexibility shows whenever the job experience (no experience, 1-2, 3-5, 6-10, over 10 years) increases, the interest in flexibility increases as (173.5, 207, 218, 232.4, 239.4) respectively. The mean rank for complying with sustainability standards and guidelines and SE development methods shows that users with a low number of years of experience, 1-2 years, have an interest in complying with sustainability standards and guidelines and SE development methods over other groups, as (180.3, 252.3, 241.5, 217, 224) respectively.

4.3 Research question 2

The study investigated three main barriers to the adoption of sustainable e-government, identified from the literature, as seen in Figure 3 which answers the second research question. The first barrier is related to policymakers' mission to improve public awareness of the benefits of using sustainable e-services, including e-government. Dzhusupova et al. (2011) found that there had been little research into the challenges, including low levels of awareness, facing developing countries in their efforts to undertake sustainable e-governance initiatives. Abu-Shanab and Al-Quraan (2015) report a significant positive relationship between citizens' awareness of e-government projects and sustainability. Related research indicates that in order to ensure sustainable software engineering , it is essential to raise awareness among business analysts and developers of the benefits of sustainability in the software industry (Penzenstadler, 2014), as is also indicated within the KSA context (Aljarallah and Lock, 2019b).

Meeting users' future generation needs was considered the second barrier, with considering the current users' requirements the third barrier which arises when developing sustainable e-government systems. Al-Khouri (2013) argues that existing practice in the e-government field reflects the difficulties of ensuring that such complex systems meet current needs. Considering the Brundtland (Sheldrick, 2015) definition of sustainability, sustainable e-government systems must be designed to meet the next generation's needs. However, it is unclear how they can be expected to do so if their development does not satisfy current needs and take account of their dynamic nature. These considerations highlight a number of issues which are critical to the sustainability of e-government systems, namely predicting future needs, identifying the effects of existing e-government systems in the short and long term and mitigating the negative influence of e-government services on the sustainability dimension.

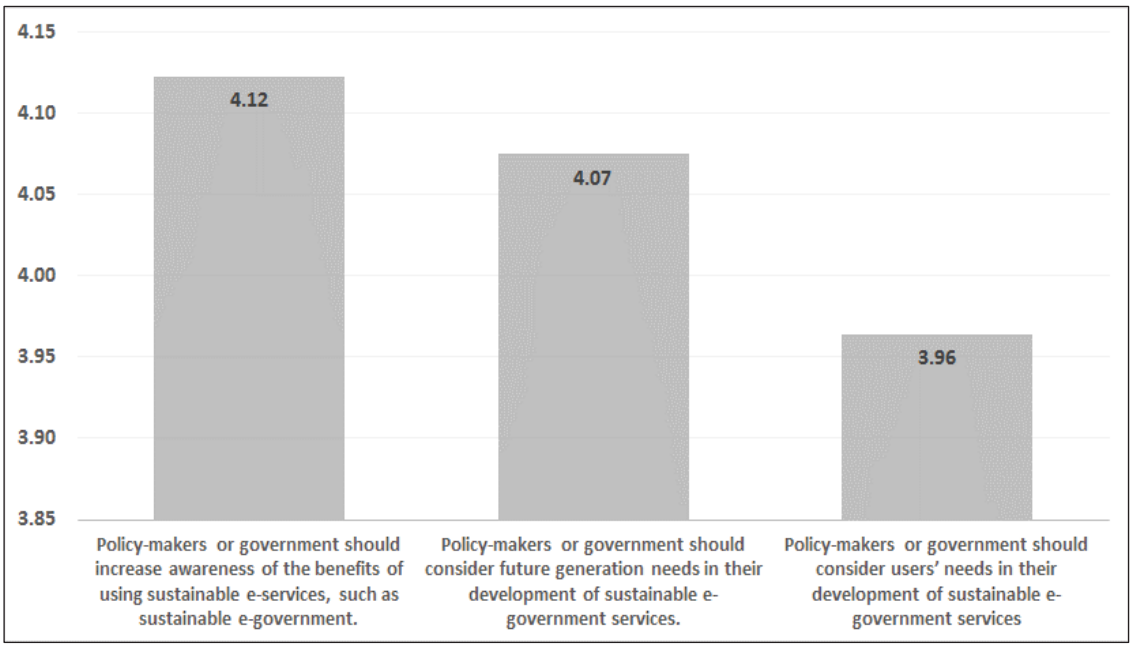

Figure 3: Mean ranking for sustainable e-government barriers

Calculation of mean scores on survey items related to the above barriers reveals little difference among them in their perceived importance. While failing to distinguish clearly among them in terms of importance, the results are consistent with findings in the literature that these are three key barriers to sustainable e-government.

4.4 Research question 3

Experts were asked to evaluate aspects of sustainable e-government to answer the third question. Figure 4 shows the responses for the six questions on sustainable e-government systems. Respondents show a positive relationship between software sustainability and successful e-government system services. Software sustainability is seen as a contributor to e-government projects; however, this result could be debatable since understanding of software sustainability differs among the study sample.

Supporting sustainability in e-government models and frameworks is questionable, since the result shows 41% have no opinion whereas 42% favour sustainability support; however, results can be subject to respondents' interpretation. Arguably, sustainability can be partly but not explicitly supported, as reflected in respondents' results. Stürmer (2014) affirms that digital sustainability is still a challenge for e-government. A study by Chitchyan et al. (2016) shows some barriers to sustainability within SW originations, including lack of methodology and tool support. Penzenstadler (2014) warns the lack of sustainability policies and standards could prevent inclusion of sustainability requirements within any developed system. Aldabjan, Haines and Jay (2016) affirm the lack of guidelines to achieve software sustainability. Within low infrastructure countries, Khamis and Weide (2016) report no sustainable solutions for e-government systems. This reflects a lack of framework, methods and tools that support sustainable e-government implementation. Wolfram, Lago and Osborne (2017) report lack of official standards and models that support sustainability within the software industry. This can be applied in e-government in its software context.

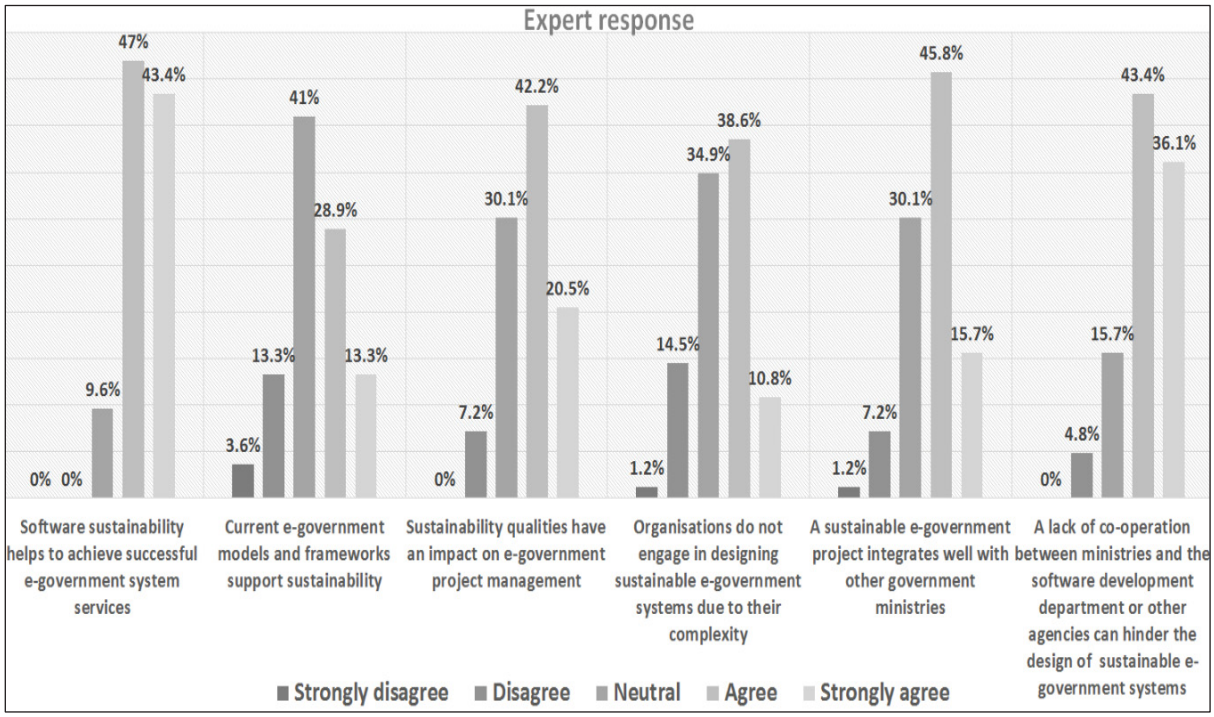

Figure 4: Experts' response for sustainable e-government aspects

Nearly half of the sample agrees that complexity of designing sustainable e-government system hinders their organisation from engaging with it. More than one-third have a neutral opinion that reflects mid-level uncertainty. In the software context, Cabot et al. (2009) and Venters et al. (2014) describe dealing with sustainability as a complex multi-stakeholder problem, whereas Mahaux and Canon (2013) describe dealing with complexity in software projects as an overlooked topic. In the software industry, Roher and Richardson (2013) report an intellectual barrier as the software industry might not be keen on adding significant complexity in software development by including sustainability because complexity increases cost.

Indeed, services integration considers one of the major challenges in the e-government literature that covers several stakeholders (Sarikas and Weerakkody, 2007; Chourabi and Mellouli, 2011). Similarly, integrating sustainable e-government services with other e-government services, which may be unsustainably implemented, could make horizontal integrations far more complex. As'ad et al. (2018) propose eight factors for achieving service integration in electronic government implementations, namely availability, consistency, accessibility, security, customization, reliability, maintainability and usability. Sustainability is not mentioned in this model; however, all these factors fall under sustainability, particularly the technical dimension.

Agreement towards co-operation between ministries and software development departments or other agencies is high compared to other previous responses. The result reflects the importance of cooperation in achieving sustainable e-government design. Kumar and Best (2006) discusses that a failure to sustain e-government can stem from failure to involve all engaged stakeholders, as well as the lack of collaboration and response of private partners for government, and changes in its environment. A study for sustainable e-governance in South Korea shows that trust in government is a reflection of quality e-government services, stressing the importance of policy existence to manage information-sharing for privacy protection, as well as managing cooperation and collaboration between government entities (Myeong, Kwon and Seo, 2014). This shows how e-government quality ties to sustainability, and the impact on one social characteristic, such as trust, on e-government systems. Other characteristics such as equity, right, privacy, etc. can have an enormous impact on e-government systems. This leads to the importance of the cooperation of government agencies and software development department on design and usage stages.

5. Discussion of the findings

Fisher (2006) reports that in order to have a sustainable, successful e-government system, the system should be adopted by a critical mass of users; otherwise, it ends up an unsustainable system which shows a relationship between adoption and success of e-government. Moreover, Heeks (2002, 2003a, 2003b, as cited by Kumar and Best, 2006) classifies e-government project failures under five aspects, namely total failure, partial failure class 1 (unattained goals), partial failure class 2 (sustainability failure), partial failure class 3 (success in specific group or region and failure in others) and success. Users' results showed showed that a high level of sustainability will increase the adoption rate of e-government systems, which reflected on the success of the system which is confirmed by experts' results; therefore, sustainability was considered an important factor in increasing users' adoption and gaining their trust by maintaining their security, and privacy and making them utilise the system with high levels of satisfaction in terms of reliability, usability and performance. Users' results proves the importance of such values (security, usability, transparency, performance and flexibility, etc.) to users who are considered major stakeholders for e-government systems as well as sustainability; however, without increasing the level of awareness which is indicated as a major barrier, consideration of sustainability concerns could become an issue since an approriate trade-off should be made which may be influenced by user experience.

An interview with 10 software development project leaders in Austria shows no explict efforts have been made to address sustainability in software projects – processes, metrics, guidelines or best practices (Groher and Weinreich, 2017). Moreover, there are no clear explicit standards, guidelines and tools for software sustainability (Rosado de Souza et al., 2019; Aldabjan, 2016; Chitchyan et al., 2016). Our findings from experts' results support these findings; however, they showed a wider perspective since the investigation of current models and frameworks went beyond software toward whole e-government systems which showed a shortage of sustainability incorporation. As the private sector can form part of e-government projects, the previous argument shows a clear lack of efforts towards sustainability, caused, as the author indicated, by lack of sustainability awareness which was shown as a major barrier and the experts' perspective as incorporating sustainability to increase complexity. . Since current e-services are not designed to be sustainable (Razavian, Procaccianti and Tamburri, 2014), e-government e-services are more likely to be unsustaianble, whereas our findings from the experts' results show 42% considered current models support sustainability. The KSA e-government system is not unique compared to other e-government systems, which reflects its need for standards, frameworks or models to adopt sustainability in the project process or the usage stage. The existence of sustainability policies, framework, models and standards is important to the software industry to enhance sustainability within societies (Penzenstadler, 2014; Penzenstadler et al., 2014). Simillary, e-government in its software context needs to be sustainable to meet the 2050 vision of sustainability, which could be done by overcoming some barriers such as increasing the awareness and meeting present and future generations' needs and developing the current models and framework, supporting integration, incorporating sustainability within

e-government projects and promoting cooperation among stakeholders toward achieving sustainable e-government system as shown in expert findings.

The majority of software sustainability research is at the conceptual level (Aljarallah and Lock, 2018b; Saputri and Lee, 2016). In the same context, since ICT covers many components including software and ICT empowers e-government to be sustainable (Ndou, 2004), achieving sustainable e-government needs more effort than sustaining software. As a result, to move toward sustainable e-government systems, the research community of e-government should shed light on this topic and move it from a conceptual level to providing a practical solution as tools, standards, frameworks or models for evaluation and testing which will help to reduce the complexity level reported from the experts' results.

Further, increasing awareness among e-government users of sustainability benefits is a barrier for users related to policy-makers in e-government, as this study reports; however, sustainability awareness is considered a barrier for end users in KSA to adopting sustainable software, whereas policy-makers' commitment to developing sustainable software is seen as the lowest barrier from an end user perspective (Aljarallah and Lock, 2018c). As a result, awareness needs to increase among users and government of the benefits of sustainability in e-government (Aljarallah and Lock, 2018a). For the sake of reduced complexity, standards, models, frameworks and tools should be developed to meet the new challenges which will witness the integration of sustainable e-government with smart sustainable cities. Understanding the impact of sustainability in e-government development projects (process level) as well as on the final product (product level) should be investigated.

6. Conclusion

This paper reports an exploration of sustainability from the perspective of e-government service users and experts in the KSA. A survey method was used to garner information from users and experts on the characteristics of sustainable e-government, the barriers to adopting sustainable e-government, and the extent to which the current sustainable e-government aspects influence developing an e-government system. The research differs from previous studies by focusing on a software context. On the other hand, the study complements the previous studies regarding e-government sustainability in its major scope, highlighting key differences between priorities reported in the literature on green-ability, in terms of both resource and energy usage, and those identified within the KSA.

Considering the users' findings regards the characteristics of sustainable e-government, addressed in RQ1, users pay significant attention to social sustainability since the findings showed trust, security and usability are usually top ranked. Flexibility or meeting current needs is one of the top characteristics for sustainable e-government, which stands clearly in the Brundtland sustainability definition. This leads to the importance of sustainability for e-government systems. The environmental dimension was ranked low among other dimensions based on its characteristics ranking, which shows the need to raise awareness of sustainability, which is also considered the top ranked barrier, and provide policies and framework to promote sustainability. This ties well with findings from the experts' survey which show the need for framework and models that incorporate sustainability during design and implementation which helps to reduce complexity. The research also investigated the importance of key barriers, addressed in RQ2, identified in the literature with regard to sustainability in the study context, confirming the importance of raising awareness of sustainable e-government benefits which are considered a major barrier followed by predicating future generation needs and meeting the needs of current stakeholders.

Findings from the expert survey, addressed in RQ3, show the importance of sustainability for e-government success; however, it also shows the need for a framework and models that support designing and implementing sustainable e-government, which is proven also in the lack of engagement from organisations to design and implement sustainable e-government due to its complexity. Cooperation between government parties can help to reduce complexity and engaging with sustainability very well which can facilitate integration between ministries toward sustainable e-government system.

In terms of future work while the suggested characteristics are limited to software and do not cover all ICT components, the proposed characteristics need to be tested and included in an e-government development framework to examine their robustness and coverage of the software aspect in sustainable e-government. Secondly, surveys data should be examined in more depth using statistics methods such as group variances,

correlations etc. which discarded in this paper due to the scope and space of this paper. Thirdly, even if the ranking scale can provide reliability and validity of the findings, it is still region-specific and the order could differ from one region to another; however, it may share the order of some of the top ranked characteristics.

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