A Goal-Oriented Requirements Engineering Framework for E-government Information Systems

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Abstract

E-government information systems projects in developing countries face several challenges that lead to their partial or total failure. Several causes of e-government information systems project failure have been identified, including inadequate requirement engineering. The overall failure rate of e-government information systems projects due to requirements engineering inadequacies is still high. Inadequate requirement engineering leads to systems with missing features, low quality, project costs, and time overrun. This research aims to design a framework to guide practitioners in e-government information systems requirements engineering processes. The design science research approach and qualitative data collection and analysis methods were applied through three iterative cycles of rigor, design, and relevancy. The proposed framework is based on goals and viewpoints requirements engineering. It consists of three models: the e-government viewpoints model, the e-government goals model, and the e-government requirements engineering process model. The framework was validated through two rounds of Delphi focus group discussion techniques and a single technical action research case study. The results showed a strong consensus among practitioners about the proposed framework's ease of use and utility with a mean agreement of 4.429/5. The technical action research involved five practitioners who applied the proposed framework to discover the requirements of the road emergency response module of road safety information systems of Tanzania. A total of 104 requirements were discovered compared to nine requirements elicited before without using the proposed framework. The overall objective of the proposed framework is to facilitate the discovery and specification of adequate and relevant requirements for e-government information systems projects and ultimately reduce the rate of e-government projects failure and contribute to the realisation of e-government benefits.

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Introduction

During the last three decades, many governments worldwide have introduced Information and Communication Technologies (ICT) in government operations. These initiatives, collectively known as e-government, aim to improve service delivery and government administrative processes (Sánchez-Torres & Miles, 2017). In service delivery, e-government

information systems (IS) have been praised for promoting people-centric services, accountability, effectiveness, and efficiency. Other benefits of e-government include improved participation, inclusion, transparency, and trustworthiness in public services.

In realizing the importance of e-government in improving service delivery, the Tanzania Information and Communication Technology (ICT) policy released in 2016 emphasizes strengthening the capacity of the institutions responsible for coordinating, providing oversight, regulating, promoting, and enforcement of e-government and other e-services initiatives. The policy calls for creating a supportive environment for collaboration with various stakeholders in developing e-government in the country.

According to the United Nations, Tanzania falls in the category of middle E-government Development Index - EGDI, which is between 0.25 and 0.50, having EGDI of 0.33533 in 2016, 0.3929 in 2018, and 0.4206 in 2020. The top five countries in Africa under this group are Rwanda with an EGDI of 0.4789 (2020), Lesotho with an EGDI of 0.4593 (2020), Uganda with an EGDI of 0.4499 (2020), Togo with an EGDI of 0.4302 (2020), and Zambia with EGDI of 0.4242 (2020). Denmark, the Republican of Korea, and Estonia are the leading countries in the world with EDGI of 0.98, 0.96, and 0.95, respectively. EGDI assesses e-government development at a national level based on available online services, telecommunication infrastructure, and ICT human capital on a scale of 0 to 1 (United Nations, 2016, 2018, 2020).

Although there has been promising progress across the continent, the implementation of e-government (IS) projects in developing countries still face several turbulences that lead to partial or total failure (Choi and Chandler, 2020). As a result, millions of taxpayers' monies are wasted. (Abbas *et al.*, 2017). It is estimated over 40% of IS project problems are caused by inadequate systems requirements specifications (Anwer *et al.*, 2019). Common RE issues include: lack of user involvements; changing requirements; missing critical requirements; incomplete requirements; ambiguous requirements; poor requirements traceability; elicitation of irrelevant requirements; and poor requirements change

management (Boota *et al.*, 2014; Hussain *et al.*, 2016; Shah & Patel, 2014).

Due to inadequate requirements engineering (RE), in many developing countries, the benefits of e-government are seen as hypes rather than reality, as citizens do not evidence them in real life to justify the considerable investment (Paulin, 2015). Most e-government systems in developing countries are not citizen-centric (Mukamurenzi *et al.*, 2019). They are designed and developed without crucial features and quality required by citizens in terms of process, service, and information. Unlike other information systems, designing and developing e-government information systems requires a thorough consideration of political, economic, socio-cultural, technological, and legal factors (Joseph & Avdic, 2016; Mkude & Wimmer, 2013).

There is still a lack of a comprehensive framework and guidelines to aid and guide the reengineering of e-government IS requirements. Few researchers have attempted to address this problem. For example, Tambouris *et al.*, 2014, developed a set of e-government IS requirements consisting of 186 requirements. The set comprised of functional, security, usability, reliability, performance, supportability, design, and interface requirements. Palkovits & Wimmer (2003) proposed a model for modelling public e-services. The framework suggests that the business process models for public service should have three sub-models; the administrative service model, the process map, and the organisational model.

This study aims to design a requirements engineering framework for e-government systems to reduce e-government project failure rates and facilitate the realisation of e-government benefits. In addressing this objective, the design science research (DSR) approach coupled with a number of qualitative data collection and analyses were applied. The Government Information System Requirement Engineering Framework (GISREF) is proposed. The framework consists of three models; the E-government Viewpoints Model (EVM), the E-government Goals Model (EGM), and the E-government Requirements Engineering Process Model (EREPM). The overall objective of GISREF is to guide the requirements engineers throughout the e-government IS RE process. This study's contributions are twofold; first, the study

provides a framework that improves analysts' understanding to discover and elicit critical requirements for e-government IS. Second, the study addresses the problem of methodology and technique in eliciting requirements for e-government IS.

The proposed framework is based on goals and viewpoints-oriented requirements engineering. Viewpoint is the perspective from which a particular thing is considered or assessed. The concept of viewpoints in requirements engineering was first proposed by (Mullery, 1979). Viewpoints describe possible diverse sources of requirements for a system under development. They provide mechanisms for the identification, organisation, and classification of system requirements. Goals play an essential role in the RE process as they provide the foundation for elaborating requirements and criteria for benchmarking the developed system (Abrahão *et al.*, 2019). Therefore, using viewpoints and goals together increases the chances for discovering critical requirements of a system.

Materials and Methods

The study adopted a design science research (DSR) approach, coupled with qualitative data collection and analysis methods, including systematic literature review, qualitative meta-synthesis, Delphi technique for focus group discussion, questionnaire, and technical action research (TAR). The research was organised in six phases of problem identification and motivation, establishing the knowledge base, design and development of the framework, validation, demonstration, and communication as illustrated in Figure 1 (Hevner & Chatterjee, 2010).
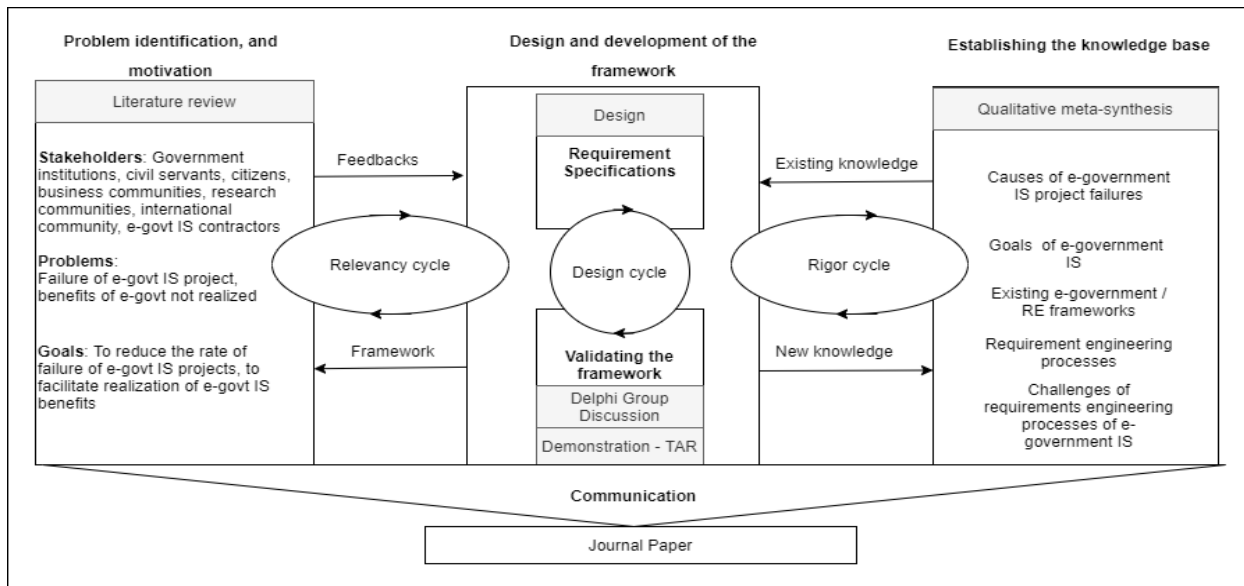

Figure 1. A research framework

Problem identification and motivation
This phase involves establishing an understanding of the environment, the context, the problem domain, and the anticipation of possible solutions. The environment and context defining the stakeholders, their problems, and their desires are summarized in Figure 1. This phase was achieved through a literature review.

Establishing the knowledge base
In achieving the objective of this study, it was important to understand the benefits of e-government IS, why e-government IS projects fail, and the challenges facing the RE process of e-government IS. This knowledge was established using qualitative meta-synthesis methodology. The researchers performed several iterations of searching for relevant articles. Popular databases were used, including Google Scholar, Association for Computing Machinery (ACM) Digital Library, Research Gate, the Institute of Electrical and Electronics Engineers (IEEE) Xplore, Springer, Wiley, and ScienceDirect. Various keywords and advanced

search techniques were performed. A total of 301 articles were obtained; 86 articles for e-government failure and 128 articles for goals and benefits of e-government. Other articles include 28 articles for the RE process and 59 articles for e-requirements engineering frameworks. These articles were reviewed to exclude those which were not relevant. The selected criteria were a journal, conference, and industry articles focusing on one of the following topics; failure and benefits of e-government systems, e-government development frameworks, and IS requirement engineering. Sixty-four articles for e-government IS failure, 126 articles for benefits of e-government, 24 articles for the RE process, and 48 articles for requirements engineering passed the selection criteria. Root cause analysis was also applied to understand and establish the root causes of the challenges facing the requirements engineering of e-government IS.

Using an emergent thematic coding approach, data were captured, analysed, and coded. A total of 27 goals of e-government were identified, as shown in Table 1; 18 factors for e-government IS project failure were identified, as shown in Table 2; 16 RE activities summarised in Table 3; 8 challenges and 36 root causes of inadequate e-government IS requirements engineering processes in Table 4.

Design and development of the framework

The requirements specifications to guide the design and development, Table 5, were derived from the list of challenges of the e-government RE process and their root cause, Table 4. In satisfying these requirements specifications, three models were designed. The E-government Goal Model – EGM, Figure 2 was created by rearranging the identified goals in Table 1 into a goal graph. The E-government Viewpoint Model – EVM was designed by organising similar goals and failure factors presented in Tables 1 and 2 into groups of themes. These themes were later re-named to represent viewpoints as presented in Tables 6 and 7 and Figure 3. The E-government Requirements Engineering Process Model – EREPM, Figure 4, was designed from rearranging RE activities shown in Table 3 and practical experience using the EGM and EVM through the technical action research.

Framework validation

The proposed framework was validated through practitioners' opinions. A two-round of Delphi focus group validation was conducted. The first round involved 15 e-government practitioners from five ministries, two agencies of the government of Tanzania, and two Non-Governmental Organisations - NGOs working on Tanzania's e-government initiatives. The second round involved seven e-government practitioners gathered from the three ministries and one executive agency from Tanzania. The selection criteria to invite the experts was based on their experience in e-government and that they had ongoing e-government IS projects with their organisations. Members were required to have at least five years of experience in developing e-government systems as recommended (Hallowell & Gambatese, 2010). The framework was presented to the practitioners, followed by a discussion, comments, questions, and answers. The practitioners were asked to complete a specific questionnaire to rate the framework's ease of use and utility. The questions were designed using a five-point Likert scale to measure the extent of agreement. The scale ranged from strongly disagree (1) to strongly agree (5). Comments and suggestions of the experts summarised in Table 8 were incorporated in the framework design.

Table 1. Goals of E-government Information Systems

S/N	E-government Goals	Literature
1	To improve effectiveness and efficiency	Ayachi *et al.,* (2016), Abu-shanab (2015), Cordella & Tempini (2015), Damodaran *et al.,* (2005), Elenezi *et al.,* (2017), Hanna *et al.,* (2009), Irani *et al.,* (2006), Jackson *et al.,* (2015), Juell-Skielse *et al.,* (2017), Kassen (2015), Kayed *et al.,* (2010), Komba & Ngulube (2014), Mawela *et al.,* (2017), Mpinganjira

		(2015), M. R. Zakaria & Gebba (2014), Owusu-Ansah (2014), Putra *et al.,* (2018), Rana *et al.,* (2015), Sánchez-Torres & Miles (2017), Stephen *et al.,* (2017), Shrivastava *et al.,* (2014), Stefanovic *et al.,* (2016), Sorn-in *et al.,* (2015), Waldt (2002)
2	To improve transparency	Abu-shanab (2015), Ayachi *et al.,* (2016), Gupta *et al.,* (2016), Jackson *et al.,* (2015), Kassen (2015), Komba & Ngulube (2014), Sánchez-Torres & Miles (2017), Shrivastava *et al.,* (2014), Stephen *et al.,* (2017), Stefanovic *et al.,* (2016), Sun *et al.,* (2015), M. R. Zakaria & Gebba (2014), Owusu-Ansah (2014), Putra *et al.,* (2018), V. D. Ndou, (2004), Waldt (2002)
3	To provide improved and convenient services	Australia. National Office for the Information Economy. & DMR Consulting. (2003), Damodaran *et al.,* (2005), Elenezi *et al.,* 2017), Jacob *et al.,* (2017), Sánchez-Torres & Miles, (2017), Shrivastava *et al.,* (2014), Stephen *et al.,* (2017), Sun *et al.,* (2015)
4	To reduce transaction costs	Ayachi *et al.,* (2016), Australia. National Office for the Information Economy. & DMR Consulting. (2003), Gupta *et al.,* (2016), Hanna *et al.,* (2009), Irani *et al.,* (2006), Jackson *et al.,* (2015), Jacob *et al.,* (2017), M. R. Zakaria & Gebba, (2014), Stephen *et al.,* (2017), Sun *et al.,* (2015), V. D. Ndou (2017), Waldt (2002),
5	To improve business processes	Damodaran *et al.,* (2005), Irani *et al.,* (2006), Jackson *et al.,* (2015), Sánchez-Torres & Miles (2017)
6	To improve accountability	Abu-shanab (2015), Gupta *et al.,* (2016), Hanna *et al.,* (2009), Irani *et al.,* (2006), Jackson *et al.,* (2015), Kassen (2015), Owusu-Ansah (2014), Rana *et al.,* (2015), Sánchez-Torres & Miles (2017), Stephen *et al.,* (2017), V. D. Ndou (2004), Waldt (2002)
7	To provide integrated services	Elenezi *et al.,* (2017), Jackson *et al.,* (2015), Juell-Skielse *et al.,* (2017), Putra *et al.,* (2018), Reffat (2003), Sorn-in *et al.,* (2015), Shrivastava *et al.,* (2014), Stefanovic *et al.,* (2016), Sun *et al.,* (2015), Waldt (2002)
8	To improve public administration and management	Abu-shanab (2015), Chutimaskul *et al.,* (2008), Irani *et al.,* (2006), Kassen (2015), Mawela *et al.,* (2017), Sánchez-Torres & Miles (2017), Stephen *et al.,* (2017), Vrakas *et al.,* (2010),
9	To improve collaboration, cooperation, coordination, and information sharing between government agencies	Damodaran *et al.,* (2005), Elenezi *et al.,* (2017), Irani *et al.,* (2006), Juell-Skielse *et al.,* (2017), M. R. Zakaria & Gebba (2014), Putra *et al.,* (2018), Sun *et al.,* (2015), Waldt (2002)
10	To improve citizen participation	Abu-shanab (2015), Kayed *et al.,* (2010), , Mpinganjira (2015), M. R. Zakaria & Gebba (2014), Reffat (2003), Owusu-Ansah (2014), Shrivastava *et al.,* (2014) , Sun *et al.,* (2015)
11	To improve accessibility and quality of government information	Elenezi *et al.,* (2017), Jackson *et al.,* (2015), Kassen (2015), Mpinganjira (2015), M. R. Zakaria & Gebba (2014), Shrivastava *et al.,* (2014)

12	To improve democracy	Abu-shanab (2015), Damodaran *et al.,* (2005), Kassen (2015), Kayed *et al.,* (2010), Mpinganjira (2015), M. R. Zakaria & Gebba, (2014), Mawela *et al.,* (2017)
13	To build trust in citizens	Jackson *et al.,* (2015), Jacob *et al.,* (2017), Mawela *et al.,* (2017), Owusu-Ansah (2014), Putra *et al.,* (2018), Reffat 92003) , Stefanovic *et al.,* (2016)
14	To improve decision making	Abu-shanab (2015), Owusu-Ansah (2014), V. D. Ndou (2004),
15	To provide reliable service (24/7)	Gupta *et al.,* (2016), Jacob *et al.,* (2017), Stefanovic *et al.,* (2016), Sorn-in *et al.,* (2015), Vrakas *et al.,* (2010), Waldt (2002),
16	To prevent or reduce corruption	Jackson *et al.,* (2015), Putra *et al.,* (2018), Sun *et al.,* (2015), V. D. Ndou (2017), Waldt (2002)
17	To increased government capacity to deliver services	(Sorn-in *et al.,* (2015), V. D. Ndou (2004),
18	To facilitate effective policy implementation	Cordella & Tempini (2015)
19	To improve the business environment	Kassen (2015), Hanna *et al.,* (2009), Waldt, (2002), Reffat (2003)
20	To facilitate inclusion of the marginalized	Abu-shanab (2015), Damodaran *et al.,* (2005), Hanna *et al.,* (2009), Jackson *et al.,* (2015), ,
21	To facilitate effective programmes implementation and management	Cordella & Tempini (2015)
22	To improved social welfare	Australia. National Office for the Information Economy. & DMR Consulting. (2003)
23	To eliminate bureaucracy	Jackson *et al.,* (2015), Waldt (2002), M. R. Zakaria & Gebba (2014)
24	To control fraud and embezzlement	Ayachi et al (2016)
25	To provide innovative services	Irani *et al.,* (2006), Kassen (2015), Sánchez-Torres & Miles (2017)
26	To provide personalized and variety of choices of services	Damodaran *et al.,* (2005), Sánchez-Torres & Miles (2017), Waldt (2002),
27	To reduce paperwork	Shrivastava *et al.,* (2014), Stefanovic *et al.,* (2016), Waldt (2002)

Table 2. Causes of E-government IS Projects Failure

	Causal factor	Literature
1	Inadequate system requirements engineering	Baguma and Lubega (2013), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Sweis (2015), Hofmann and Lehner (2001), Bubenko (1995), Michael and Boniface (2014), Zakaria *et al.,* (2011)
2	Inadequate project management	Afyonluoğlu *et al.,* (2014), Aikins (2012), Baguma and Lubega (2013), Goedeke *et al.,* (2017), Gunawong and Gao (2017), Hossan *et al.,* (2006), Imran *et al.,* (2017), Rajapakse *et al.,* (2012),(Rajala and Aaltonen (2020), Sweis (2015), S. R. A. Shah *et al.,* (2011), Twizeyimana *et al.,* (2018)
3	Missing or incomplete features	Baguma and Lubega (2013), Damoah and Akwei (2017), (Goedeke *et al.,* (2017), Gunawong and Gao (2017)
4	Inadequate project planning	Aikins (2012), Baguma and Lubega (2013), Bakunzibake *et al.,* (2018), Ghapanchi and Albadvi (2008), Goedeke *et al.,* (2017),

		Hossan *et al.,* (2006), Rajala and Aaltonen (2020), Rajapakse *et al.,* (2012), (Twizeyimana *et al.,* (2018)
5	Inappropriate choice of technology	Goedeke *et al.,* (2017), Ghapanchi and Albadvi (2008), Lau (2003)
6	Insufficient top management support	Aikins (2012), Baguma and Lubega (2013), Bakunzibake *et al.,* (2018), Goedeke *et al.,* (2017), Ojha and Pandey (2017), Sweis (2015), ,
7	Integration failure	Al-khanjari *et al.,* (2014), Ghapanchi & Albadvi (2008), Goedeke *et al.,* (2017), Lam (2005)
8	Procurement and contract shortcomings	Goedeke *et al.,* (2017), Ojha and Pandey (2017), Rajapakse *et al.,* (2012)
9	Inadequate business process management (BPM)	Afyonluoğlu *et al.,* (2014), Baguma and Lubega (2013), Bakunzibake *et al.,* (2018), Dada (2006), Goedeke *et al.,* (2017), Gartlan & Shanks (2007), Martin and Montagna (2006), Reffat (2003), (Swartz (2018), Trkman (2010)
10	Insufficient IS testing	Goedeke *et al.,* (2017), Mansor and Ndudi (2015), Rajala and Aaltonen (2020), (Rajapakse *et al.,* (2012)
11	Insufficient change management	Afyonluoğlu *et al.,* (2014), Aikins (2012), (Bakunzibake *et al.,* (2018), Ghapanchi and Albadvi (2008), Dada (2006), Hossan *et al.,* (2006), (Nograsek (2011)
12	Staffing and skills shortfalls	Abbas *et al.,* (2017), Baguma and Lubega (2013), Dada (2006), Goedeke *et al.,* (2017), Hossan *et al.,* (2006), Rajala and Aaltonen (2020), Rajapakse *et al.,* (2012), Ojha and Pandey (2017), Twizeyimana *et al.,* (2018), Zakaria *et al.,* (2011)
13	Technical over-complexity	Goedeke *et al.,* (2017), Abbas *et al.,* (2017), Botchkarev and Finnigan (2015), Sweis (2015), Lau (2003), Mukherjee (2008)
14	Obsolete technology	Baguma and Lubega (2013), Goedeke *et al.,* (2017)
15	Information gaps	Heeks (2001), Rajapakse *et al.,* (2012), Vyas *et al.,* (2014)
16	Inadequate infrastructure	Baguma and Lubega (2013), Dahiya and Mathew (2018), Bakunzibake *et al.,* (2018), Goedeke *et al.,* (2017), Hossan *et al.,* (2006), Rahman *et al.,* (2014), Twizeyimana *et al.,* (2018)
17	Political interference	Abbas *et al.,* (2017), Baguma and Lubega (2013), Hossan *et al.,* (2006), Rajala and Aaltonen (2020), Toots (2019)
18	Inappropriate organisational management structure	Abbas *et al.,* (2017), Goedeke *et al.,* (2017), Rajala and Aaltonen (2020), S. R. A. Shah *et al.,* (2011)

Table 3. Activities in RE Process

S/N	Activities
1	Requirements elicitation/gathering
2	Requirements documentation
3	Requirements analysis
4	Requirements validation
5	Requirements negotiation
6	Requirements verification
7	Requirements modelling

8	Requirements management
9	Data analysis
10	Behavioural analysis
11	Functional analysis
12	Requirements specification
13	Problem analysis
14	Feasibility study
15	Structural analysis
16	Architectural analysis

Framework demonstration

The proposed framework was tested using a real-world problem through single technical action research. A team of five officials from institutions responsible for road safety and emergency services in Tanzania applied the framework to discover the requirements of the road emergency response module (RER) of the road safety information system. The team was comprised of two IT officers, one police officer, one emergency medical officer, and one road safety engineer. This system was planned to be implemented by the Tanzania National Roads Agency – TANROADS and Muhimbili National Hospital – MNH. The main objectives of this system were to establish an emergency call centre and an ambulance dispatch centre. Nine high-level requirements were established before the use of the proposed framework.

Table 4. Challenges of E-government IS Requirements Engineering Processes

S/N	Challenge	Root Causes	Reference
1	The challenge of understanding	Unclear project objectives and goals among stakeholders A vague understanding of needs among stakeholders. Inadequate or no feasibility study is conducted Inadequate user involvement – prospective users (citizens) not involved Limited understanding of technology capabilities and limitations among systems and business analysts Limited understanding of business processes (domain knowledge) among systems analysts. Limited understanding of RE knowledge among systems and business analysts. Limitations of natural languages/ communication difficulties. Inconsistency and terminology conflicts.	Baguma and Lubega (2013), Bubenko (1995), Brewer *et al.,* (2006) ,Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface (2014), Zakaria *et al.,* (2011), van Velsen *et al.,* (2009)

		Business process flows and use-cases not captured for all user groups and scenarios	
		The top management team are not aware of the importance of RE	
		Differing perspective among stakeholders	
2	The challenge of volatility	Lack of formal changes management procedures. Frequent change of policies acts, and administrative structures Poor information capturing and management during the RE process Changes in project scope	Bubenko (1995), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface (2014), Zakaria *et al.,* (2011)
3	The challenge of resources (staff, time, and financial)	Insufficient financial resources Insufficient human resources Inadequate RE skills among RE team Political pressures to complete the project within a short time Limited professional specialization within units or department responsible for e-government.	Baguma and Lubega (2013), Bubenko (1995), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface (2014), Zakaria *et al.,* (2011), van Velsen *et al.,* (2009)
4	The challenge of standards, methodology, and techniques	RE standards, methodologies, and techniques not known RE standards, methodologies, and techniques not correctly applied Business rules are not captured correctly. Incomplete or inadequate documentation of requirements	Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Sweis (2015), Hofmann and Lehner (2001), Bubenko (1995), Michael and Boniface (2014), Zakaria *et al.,* (2011)
5	The challenge of tools	Lack or inadequate RE tools Inadequate fund to purchase the necessary tool Tools not known	Goedeke *et al.,* (2017), Sweis (2015), Hofmann and Lehner (2001), Bubenko (1995), Michael and Boniface (2014), Zakaria *et al.,* (2011)
6	Limited prospective users involvement	Lack of effective tools Lack of sufficient methodology to involve users, especially citizens, because of their diversity.	Baguma and Lubega (2013), Bubenko (1995), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface (2014), Zakaria *et al.,* (2011), van Velsen *et al.,* (2009)
7	The challenge of diversity and complexity	Availability of a diverse number of users with varying characteristics (heterogeneous user groups). Multiple operating scenarios and environments	Baguma and Lubega (2013), Bubenko (1995), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface

		Multiple stakeholders and integration partners	(2014), Zakaria *et al.,* (2011), van Velsen *et al.,* (2009)
		Lack of clear guideline / documentation to enable the development of interoperable e-government systems	
		The complexity of some government domains	
8	The challenge of legal frameworks	Availability of multiple laws, regulations, and guidelines supporting business operations	Baguma and Lubega (2013), Bubenko (1995), Goedeke *et al.,* (2017), Hussain *et al.,* (2016), Simonofski *et al.,* (2018), Sweis (2015), Hofmann and Lehner (2001), Michael and Boniface (2014), Zakaria *et al.,* (2011), van Velsen *et al.,* (2009)

Table 5. Requirements specifications for the design of the framework

| S/N	Challenge	Requirements Specification for the Design of the Framework
1	The challenge of understanding	1. The framework should facilitate the discovery and elaboration of e-government IS objectives and align them to both sector strategies and the IS to be developed. 2. The framework should facilitate the discovery, analysis, and resolution of requirements for each identified objective from multiple ideas, perspectives and stakeholders. 3. The framework should facilitate capturing and analysis of business processes and business rules for each scenario and use case.
2	The challenge of standards, methodology, and techniques	4. The framework should provide a simple step-by-step method for the e-government IS requirement engineering process.
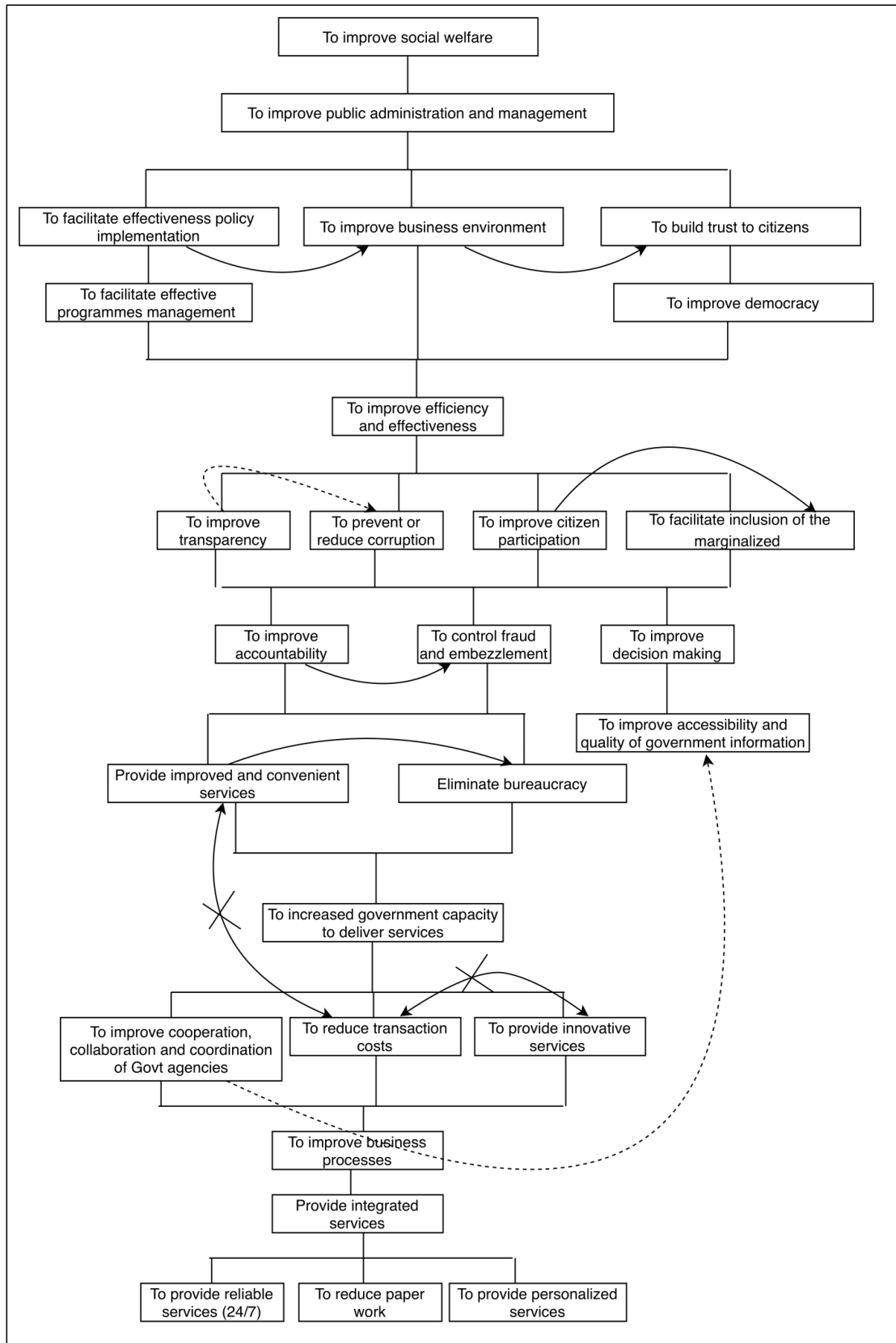
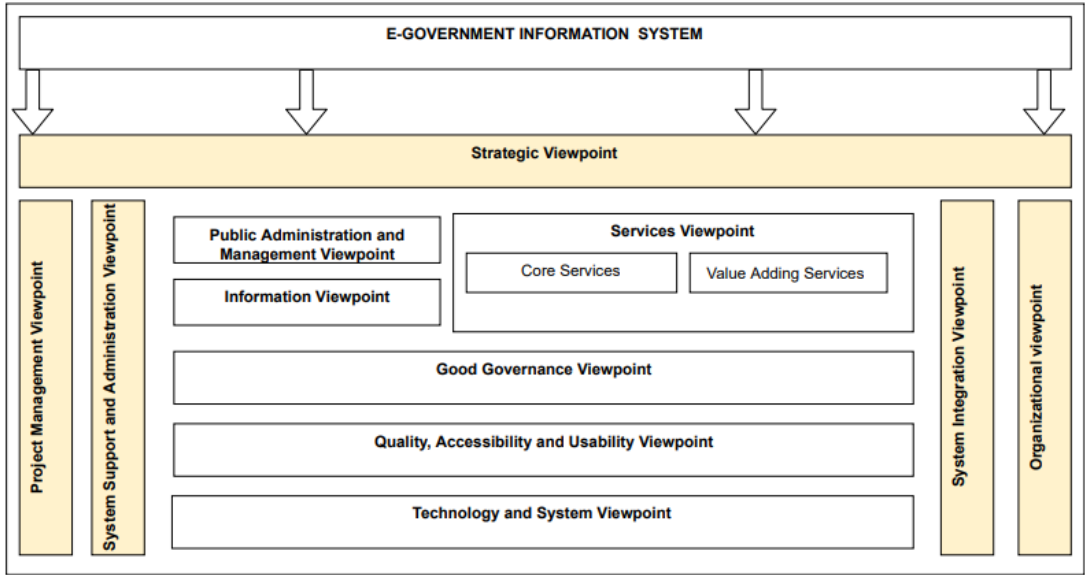*Figure 2. E-government Goals Model (EGM)*

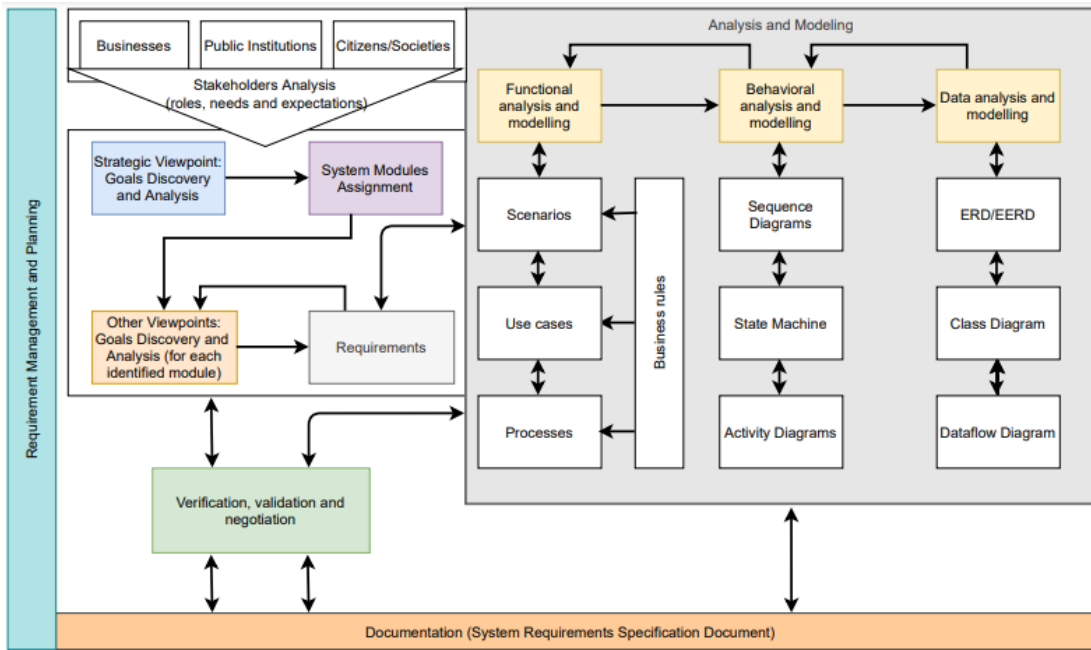*Figure 3. E-government Viewpoints Model*

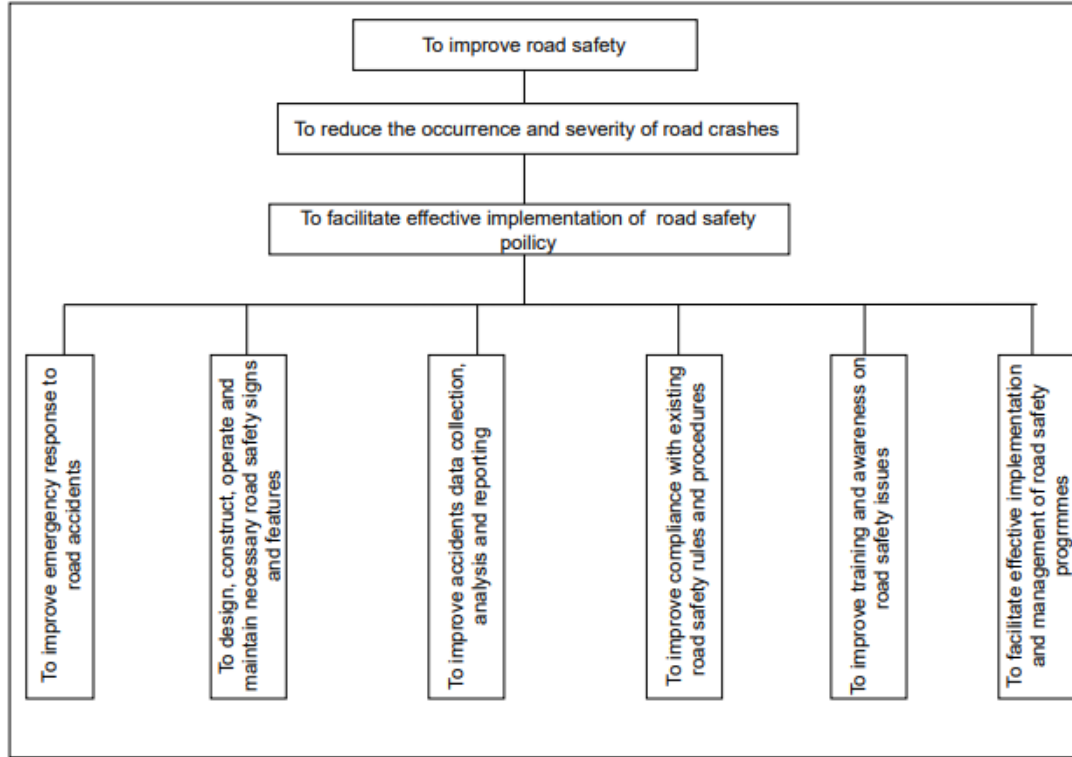*Figure 4. E-government Requirements Engineering Process Model (EREPM)*

Figure 5. Strategic goal model for road safety information system

Table 6. E-government Viewpoints from Goals Perspective

S/N	Goals	Viewpoint Name
1	1. To improve public administration and management 2. To facilitate effective policy implementation 3. To facilitate effective program implementation and management 4. To improve efficiency and effective	Public administration and management
2	1. To improve accessibility and quality of government information	Information
3	1. To eliminate bureaucracy 2. To improve business processes 3. To reduce transaction costs 4. To reduce paperwork	Core Services
4	1. To provide personalized services 2. To provide innovative services	Value-add services
5	1. To prevent corruption 2. To improve democracy 3. To improve accountability 4. To improve transparency 5. To improve citizen participation 6. To provide inclusive services	Good governance

	7. To control fraud and embezzlement
	8. To improve decision making
	9. To build trust in citizens

| 6 | 1. To provide reliable services (24/7) | Quality, accessibility, and usability |
| | 2. To provide improved and convenient services | System Support and Administration |

| 7 | 1. To improve cooperation, collaboration, and coordination of government agencies | System integration |
| | 2. To provide integrated services | |

Table 7. Viewpoints from E-government IS failure Causes Perspective

S/N	Causal Factors	Viewpoint Name
1	1. Poorly or inadequate projects planning	Strategic
2	1. Inadequate project management 2. Insufficient testing 3. Inadequate system requirements engineering 4. Lack of top management support 5. Missing or incomplete features 6. Procurement and contractual issues 7. Political interference	Project management
3	1. Inadequate business process management (BPM). 2. Lack of or insufficient change management. 3. Inadequate organisation management structure 4. Shortage of staff and lack of or inadequate skills 5. Information gaps	Organisational
4	1. Integration failure 2. Obsolete technology 3. Inappropriate choice of technology 4. Inadequate infrastructure 5. Technical complexities and problems	Technology and systems

Table 8. A summary of main areas received comments and suggestions from practitioner

S/N	Main Area	The number of participants mentioned
1	Organisational change management	6
2	System integration	4
3	Project implementation risks	3
4	Relationship between viewpoints	3
5	Application of the framework in the agile environment	3

Results

The purpose of the research was to develop a RE framework of the e-government IS project that could reduce e-government IS projects' failure and facilitate the realisation of e-government benefits. The Government Information System Requirements Engineering Framework is proposed. The framework consists of three models, the E-government Goal Model, the E-government Viewpoint Model, and the E-government Requirement Engineering Process Model.

The E-government Goal Model

The E-government Goal Model – EGM presented in Figure 2 is intended to be used by e-government IS requirements engineers as a reference model for eliciting goals for specific e-government IS. Elaborating these goals into sector-specific systems will yield several hard and soft goals to be fulfilled by the envisaged IS. The model consists of twenty-seven (27) generic goals to be fulfilled by any particular e-government IS.

E-government Viewpoints Model

The E-government Viewpoint Model - EVM presented in Figure 3, consists of twelve (12) e-government IS viewpoints: four (4) viewpoints from e-government IS project failure perspective; strategic, project management, organisational, technology, and systems viewpoints; and eight (8) viewpoints from e-government IS goals perspective; public administration and management, core services, value-adding services, information, good governance, system integration, quality, accessibility and usability, and system support and administration viewpoints. This conceptual model is intended to be used by requirements engineers of e-government IS as a reference model to enable them to partition the e-government IS in multiple perspectives during RE. Additional viewpoints and sub viewpoints in specific problem domains can also be established. The twelve viewpoints are described in the coming subsections.

Strategic

In this viewpoint, the e-government IS project objectives, goals, and values are identified and analysed. Corresponding requirements are also established. While the system may not directly implement goals and requirements in this viewpoint, they mainly serve three purposes: first, they provide benchmarking criteria for evaluating the system; second, they provide means for identifying IS modules; lastly, they help in the identification and elaboration of goals and requirements in other viewpoints.

Public administration and management

In this viewpoint, goals, and requirements to be considered are those related to improved public administration and management, effective policy implementation, improved efficiency and effectiveness, and effective programmes management. Other elements to consider in this viewpoint include; performance management, managing by results, value for money, effective resources utilization, effective planning, elimination of bureaucracy, customer-focused, etc. (Lufunyo, 2014).

Services

In this viewpoint, services to be offered to different stakeholders are identified. Corresponding goals and requirements are elicited and analysed. The goals in viewpoints include those related to the provision of improved and convenient services, improved business processes, reduction of operation costs, elimination or minimization of bureaucracy, provision of integrated services, personalized services, and reduction of paperwork. The service viewpoint has two sub-viewpoints; core services and value-adding services. Core services correspond to the fundamental services of the government institution implementing the e-government system. On the other hand, the value-adding services correspond to supplementary services that can be offered to take advantage of the new technology and add value to both stakeholders and the institution. Value-adding services correspond to the goal of offering innovative services.

Information
This viewpoint is concerned with the e-government IS requirements to facilitate improved access and quality of government information in terms of accuracy, timeliness, relevance, precision, and completeness (Oliveira & Eler, 2017). It is also concerned with analysing information to be capture from users to facilitate government operations, service provision, and decision making.

Good governance
This viewpoint is concerned with engineering e-government IS for good governance. The main question that requirements engineers should ask is how the system in question will improve; accountability, transparency, citizen participation, the inclusion of disadvantaged groups, the rule of law, decision making, and other good governance aspects.

Quality, accessibility, and usability
This is a cross-cutting viewpoint. It is concerned with the quality, accessibility, and usability requirements of e-government systems, commonly known as non-functional requirements.

Technology and system
This viewpoint is about establishing requirements for the core technologies to be used to implement the e-government system. It includes requirements for e-government infrastructure related to hardware platforms, software platforms, and connectivity technologies.

System integration
Government institutions do no operate in isolation. They rely upon one another either vertically or horizontally. In this viewpoint, goals and requirements should be elicited to improve cooperation, collaboration, coordination of government agencies, and provision of integrated services.

Organizational
This viewpoint focuses on organisational requirements for the successful implementation and adoption of the proposed system. The RE team must identify all changes and improvements required by the organisation regarding structure, business processes, staff requirements, job profiles, etc. While this viewpoint's goals and requirements may not be used directly to implement the system, they are essentially useful in developing the organisational changes management plan.

System support and administration
In this viewpoint, goals and requirements for supporting and administering the system are discovered to ensure adequate users support and administration of the system.

Project management
In this viewpoint, the RE team should identify project management requirements, including project management activities, system development methodology, schedules, milestones, project management tools, people, and their responsibilities, risks, mitigation measures, and resource requirements for the upcoming phases. The goals are requirements from this viewpoint may not be directly implemented in the system; however, they are helpful in making the project successful.

E-government Requirements Engineering Process Model
In fulfilling requirements 3 and 4 of the framework requirements specification shown in Table 5, the EREPM presented in Figure 4 was designed. The objective of this model is to guide requirement engineers throughout the RE process of the e-government IS. It elaborates how the EGM and EVM are applied in the RE process. The process is narrated in the below subsections.

Stakeholders Analysis
The first step in the RE process of the e-government system is to perform stakeholder's analysis. E-government IS tending to have several stakeholders with varying needs and operating environments. For the successful e-government IS project needs of each stakeholder must be satisfied by the system. Therefore, the needs and operational characteristics of each stakeholder should be considered throughout the RE process.

Strategic viewpoint analysis
Strategic goals are discovered and analysed. The strategic goals can be found in the feasibility

study, policy documents, strategic documents, and other reports. The leaf goals of the strategic goal graph model are assigned to modules to identify information system modules required to fulfill the strategic goals of the sector or institution developing the e-government IS.

Other viewpoints analysis

Once the e-government IS modules have been identified, each identified module is analysed separately in each viewpoint. Goals are discovered, analysed, and translated into user requirements.

Requirements Analysis

User requirements are further analysed in terms of functionality, behaviour, and data requirements to establish system requirements specification (SRS). Several methods and techniques for analysing and modelling system context, processes, data, behaviour, and structure have been proposed, such as scenarios, use cases, process, sequence diagrams, activity diagrams, and entity-relationships diagrams.

Framework Validation Results

The results are summarised in Table 9, indicate a strong agreement consensus among practitioners about the ease of use and utility of GISREF with a mean agreement of 4.429 equivalent to 88.6%, which is above the minimum percentage of agreement which was taken to be 75%, equivalent to 3.750 points. Practitioners suggested two viewpoints, system integration, and system support and administration, to be added to the EVM. There were different views on the application of the framework in an agile environment. However, it was agreed that the requirements from different viewpoints could be discovered at different times, making the framework applicable in an agile environment.

Table 9. Validation questionnaire results

Questions	Experts							
	A	**B**	**C**	**D**	**E**	**F**	**G**	**MEAN**
A: Ease of use	4	5	4	4	5	4	4	4.286
1. The framework is easy to learn and understand								
2. The framework is easy to use	3	4	4	4	5	4	4	4.000
3. The use of the framework can yield more e-government IS requirements	5	5	5	4	5	5	5	4.857
B: Adequacy and Utility								
4. The framework stimulates thinking and imaginations of requirement engineers	5	4	4	4	5	5	4	4.429
5. If applied, the framework can help to reduce the rate of e-government IS failure	5	5	5	4	5	5	5	4.857
6. If applied adequately, the framework can help to facilitate the development of citizen-centric e-government IS	4	5	4	4	4	4	4	4.142
7. If applied, the framework can facilitate the realisation of the benefits of e-government	5	4	4	4	5	5	4	4.429

Technical Action Research

The technical action research involved five practitioners who applied the proposed framework to discover the requirements of the road emergency response (RER) module of road safety information systems (RSIS) of Tanzania. A total of 104 requirements were discovered, with 14 requirements in the core services viewpoint compared to nine requirements elicited before without using the proposed framework. None of the requirements in other viewpoints was elicited before. The distribution of the requirements in various viewpoints is shown in Table 10. These results demonstrate the capability of the proposed framework in assisting requirements engineers in discovering more requirements. Therefore, if properly applied, the framework has the potential to minimize the rate of failure of e-government IS project failure and facilitate the realisation of e-government IS benefits.

Table 10. Number of requirements identified for the road emergency response system

S/N	Viewpoint	Number of Requirements
1	Organisational	10
2	Public administration and management	15
3	Information	5
4	Core services	14
5	Value-adding services	6
6	Good governance	19
7	Quality, accessibility, and usability viewpoint	14
8	Technologies and system viewpoint	2
9	System integration viewpoint	5
10	System support and administration viewpoint	7
11	Project Management	7

Discussion

Despite that RE is an old field of study and has been researched a lot in literature, very few frameworks for RE of e-government IS exist. This may be because e-government is a relatively new topic that emerged and has gained popularity in the last two decades. The limited literature on the e-government RE framework implies that requirements engineering in the public sector is an area of study that has not been prioritized. It also suggests that RE processes in e-government IS projects are currently conducted haphazardly without adequate guidance, contributing to the high number of e-government IS project failures.

For example, the road emergency response system proposed by TANROADS aimed to establish emergency medical services call centre and an ambulance dispatcher centre at the Muhimbili National Hospital (MNH). Initially, the system had nine high-level user requirements only. However, with the aid of the proposed framework, 104 high-level requirements were discovered in all twelve viewpoints. The additional requirements found through the use of the framework include those aimed to improve coordination among responsible agencies, monitor the performance of staff, supporting institutional structure and changes required for the system to work, and citizen participation. Other additional requirements discovered include those aimed at providing convenient services through integration with other available systems and providing quality and timely information to the public. All these critical requirements were left out in the initial RE phase.

Traditional RE frameworks and models have several limitations in ensuring a satisfactory RE process, especially in the public sector. Several generic RE frameworks, such as that proposed by Pandey *et al.*, 2010, exist. These frameworks focus more on the process (how) rather than the system goals. On the other hand, the available e-government RE framework, such as the one suggested by Tambouris *et al.*, 2014 and Palkovits & Wimmer, 2003, partially addresses the system goals but completely ignores the process (how). For example, the framework proposed by Palkovits & Wimmer, 2003, suggests different models for modelling public services; however, it

does not show how those models are developed. It also doesn't explore all e-government IS contexts such as integration and information.

GISREF has been designed to address most e-government IS RE aspects, such as process, goals, and offerings. If properly applied, it has the potential to eliminate or minimize defects in the RE processes of e-government IS projects. The framework stimulates the thinking and imaginations of analysts and eventually helps them discover and elicit more and useful e-government IS requirements. The framework first suggests breaking the e-government IS into twelve (12) viewpoints. By doing this, an analyst breaks the complex task into smaller and manageable tasks. The twelve (12) viewpoints were carefully identified to ensure that all requirements for particular e-government IS are elicited and specified accordingly.

In addition to that, GISREF introduces a concept of the core and value-adding services in RE of e-government IS. Value-adding services correspond to supplementary services that can be offered by the government institution to take advantage of the new technology. These services could not be provided previously because of the lack of a mechanism to provide them. For example, the government health facility using the Health Facility Management Information System can send SMS reminders to parents to remind them about the next vaccination date for their new-borns. It is common among most government organisations to implement e-government systems for only core services and thus failing to innovate new services to take advantage of the technology.

Heeks (2001) developed the design – reality gaps model centred around seven dimensions of Information, Technology, Process, Objective and values, Staffing and Skills, Management structures and systems, and Other resources, abbreviated as ITPOSMO. The gaps between the design and reality in these seven (7) dimensions must be minimized to ensure the successful implementation of the e-government IS project. Successful implementation of e-government IS in an organisation requires proper alignment of people, process, technology, and partners. The organisational viewpoint was introduced to capture organisational requirements to implement the new e-government IS. In this viewpoint, requirements for new organisation structure, staff, skills, collaborating partners, and processes are elicited and analysed while keeping the design-reality gap as minimal as possible. The goal is to identify organisational changes required to implement, use, and adopt a new system; and smoothly manage the transition from the old to the new structure and processes. For example, in the RER case study, for the system to function as anticipated, it required several changes in terms of organisational structures and staff job profiles. However, these changes were not documented as prerequisites requirements for establishing the systems.

Most e-government IS projects fail due to inadequate project management. Implementation of e-government projects should adopt and use proven project management methodologies and tools. To address this problem, EVM includes a project management viewpoint. In this viewpoint, the analyst should identify project management requirements for the successful development and implementation of e-government IS in question.

The e-government goals model (EGM) is a goal reference model that helps analysts elicit goals for different viewpoints. The model's generic goals should be translated into specific goals of the e-government IS project in question. For example, during the case study, nine strategic goals for the road safety information system were identified. The topmost goal was "To improve road safety." RER module was assigned to the goal "To improve emergency responses to road accidents." The use of goals in RE assists in triggering analysts' reasoning hence yielding more hidden requirements.

Conclusion

The benefits associated with the implementation and use of e-government IS does come for granted. E-government IS must be engineered to offer those benefits from the early stage of RE. Emerging technologies such as artificial intelligence (AI), cloud computing, quantum computing, and blockchain are expected to revolutionise the way governments work and deliver services. These technologies open up

more government opportunities to develop and implement e-government IS, which are citizen-centric, user-friendly, and offer personalised services. However, developing and implementing e-government systems to take advantage of these new technologies is even more complicated than today's e-government systems. Implementing such solutions will require a lot of work and effort to plan, analyze the requirements, design the data exchange, and coordinate mechanisms of various services offered by various government agencies. The proposed framework attempts to addresses two out of eight identified challenges of RE of e-government IS. Therefore, future research should focus not only on testing and improving the proposed framework but also on attempting to address other remaining challenges.

The framework proposed in this study, if properly applied, has the potential to facilitate adequate requirement engineering of complex e-government systems and eventually enable governments to benefit from the use of e-government IS and information technology in general.

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