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Validation of a Developed Enterprise Architecture Framework for Digitalisation of Smart Cities: a Mixed-Mode Approach

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Abstract
To support smart cities in aligning information technology (IT) and business strategies to achieve urban digitalization, this study aims to present an Enterprise Architecture Framework (EAF) to facilitate the digitalization of urban environments. Technology Acceptance Model (TAM) was employed to design a research model, and a mixed-mode methodology was employed. Quantitative data from survey questionnaires was used to gather data from practitioners in enterprises within Norway and Ireland that currently adopt Enterprise Architecture (EA) in a smart city project to empirically validate the developed EAF. Additionally, the developed EAF layers were validated through a qualitative focus group workshop with participants that utilize the developed EAF to provide digital services in smart cities. The findings suggest that the developed EAF can aid enterprises that provided digital services in identifying and assessing their digitalization initiatives and how EA benefits can be realized. Drawing on the TAM, the developed research model presents factors that influence practitioner's adoption of EA towards the digitalization of urban environments. More importantly, this study provides empirically validated research on EAF adoption which is scarce.

Keywords Information systems · Enterprise architecture adoption · Enterprise architecture framework · Technology acceptance model · Smart cities · Mixed-mode approach

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Introduction

The convergence of digital revolution and increased global urbanization has led to the development of smart cities. The complexity associated with smart cities demands innovative solutions (Tanaka et al., 2018). But smart city planning requires the management and governance of deployed information technology (IT) systems and business strategies to maximize economic benefits, increase societal benefits, and decrease environmental damage. Thus, transforming cities into digitalized urban space referred to as “Smart Cities” is important (Bokolo et al., 2021a). Nowadays, for cities to achieve successful digitalization of urban environment, both private and public enterprises that provide services within the city need to be able to quickly adapt to changing citizen requirements (Ilin et al., 2017). The prompt and efficient interoperability and infrastructural flexibility within cities are required to address the changing business requirements, which are essential for smart city actualization (Toh et al., 2009). Likewise, due to the level of complexity and increased scope of smart cities, there is a need for use of architecture or logical construct to describe, integrate, and manage Information and Communications Technology (ICT) system and data components (Alwadain et al., 2016; Bokolo & Abbas Petersen, 2021).

Accordingly, enterprise architecture (EA) is adopted by practitioners to help enterprises adapt themselves towards transformation and changes needed to strive in the digitalization era (Banaeianjahromi & Smolander, 2016). Likewise, many scholars argued that EA can be adopted as the ultimate solution to achieve digitalization in urban environment (Banaeianjahromi & Smolander, 2016; Bokolo, 2021a; Tanaka et al., 2018). EA is a discipline that helps institutions plan, analyze, design, and execute their actions utilizing ICT to obtain satisfactory deployment of their strategies (Tanaka et al., 2018). EA provides a set of definitions, models, and detailed description of the structure of an organization, its divisions, and the relationships with the external environment. It also captures terminologies employed by the organization and guiding principles for the design and development of an organization (Alaeddini & Salekfard, 2013). EA is conventionally represented in a multi-layered form (Ilin et al., 2017), as a holistic method encompassing an enterprise’s technical infrastructure, capabilities, processes, data, and information systems (IS) (Niemi & Pekkola, 2016).

EA provides a medium to acquire, conceptualize, maintain, and retain knowledge about the enterprise, structure, and its behavior (Alwadain et al., 2016). EA are employed as frameworks which comprise of comprehensive set of organized models that describe the structure and functions of an organization implicitly defined in enterprise architecture frameworks (EAFs). An EAF includes reference models, process models, artifact descriptions, guidance, techniques, and tools which are utilized by enterprise architects in the design of enterprise-detailed architectural description (Alwadain et al., 2016). Enterprise architecture framework has been adopted in urban environment as a tool to advance city’s digitalization goal in creating coherence and improving interoperability of enterprise information systems (Anthony Jnr, 2021a). EAF is aimed at reducing the gap between high-level organizational policies and low-level information systems implemented for digitalization of urban environment (Bokolo et al., 2021b).

Presently, the digitalization of cities into smart cities requires achieving interoperability and infrastructural flexibility within cities to address the changing business requirements which is not well investigated in the literature (Aguilar et al., 2020; Bokolo & Abbas Petersen, 2021). Likewise, irrespective of the benefits of EAF in smart cities, the acceptance of EAF remains a central concern in smart city research and practice (Bokolo et al., 2021b). This is because current EAF are complex and/or too abstract to be utilized in practice leading to EAF not well integrated into enterprise process (Van Der Raadt et al., 2008). Besides, there are fewer studies that provide evidence of the acceptance of EAF and benefits to be derived from the adoption of EAF in digitalization of urban environment (Espinosa et al., 2011; Bokolo et al., 2021b).

Therefore, the purpose of this study is to present a EAF proposed to support interoperability and infrastructural flexibility within cities to address the changing business requirements. The presented EAF helps to advance city's digitalization goal in achieving a coherence and improving interoperability of human and technical infrastructures deployed in smart city. Additionally, this study aims to examine theses following research questions:

- What is the role of EAF in digitalization of urban environment?
- What are the factors that influence the acceptance of EAF by practitioners in urban environment?

The originality of this study is that this research introduces a research model grounded on technology acceptance model (TAM) to empirically validate the acceptance of the developed EAF by practitioners involved in a smart city project. Quantitative data was collected using survey questionnaires, and qualitative data via focus group session was collected to validate the developed EAF from practitioners involved in a smart city project in Norway and Ireland. This study is structured as the second section is the theoretical background. The third section describes the developed enterprise architecture framework and research model development. The fourth section explains the methodology. The fifth section is the results from quantitative and qualitative data collected. The sixth section is the discussion. The last section is the conclusion and implications.

Theoretical Background

Overview of Digitalization in Urban Context

The continuous increase in urbanization is an international concern as it is projected that 68% of the world's inhabitants will be residing in cities by the year 2050, and accordingly, municipalities are deploying ICT as a major enabler for digitalization of cities into "smarter cities" (Hinkelmann et al., 2016; Bokolo et al., 2021a). A smart city is an innovative city that utilizes Information and Communication Technology (ICT) and other resources to improve citizens quality of life, the productivity of city's operations, competitiveness, and services (Aguilar et al., 2020; Tanaka et al., 2018). Additionally, a smart city is a complex socio-technical system that comprises of inter-reliant resources of people, technologies, and data that interact with each other and their deployed environment to achieve sustainable development goal of the city (Hinkelmann et al., 2016; Tsoutsa et al., 2020).

Therefore, cities are digitally transforming into smart cities to provide improved digital service to their citizens using ICT as a main enabler (Gobin-Rahimbux et al., 2020). Moreover, cities are faced with the challenge to thrive in an ever-changing environment. Researchers such as Oliveira et al. (2021) contributed to literature on environmental regulations and digitalization and provided understanding on business-to-business organizations (health, education, industry, trade, and services) in Portugal in the age of paperless processes and digitalization. Similarly, to support digital transformation of cities according to emerging cities demands, a holistic perspective is required for environmental protection as advocated by Oliveira et al. (2021), to be employed as also suggested in the literature (Romero & Vernadat, 2016; Tanaka et al., 2018).

Accordingly, the vision of smart cities entails shifting from the traditional urban operation to the latest digital capabilities including cloud computing, virtualization, big data analytics, social web, Internet-of-Things (IoT), omni-channels, and digital twin (Komninos et al., 2021; Romero & Vernadat, 2016). According to Gartner, cities are facing a new era of urban IT deployment termed the "digitalization" era, a period characterized with the use of digital technologies for more integrated urban services (Hinkelmann et al., 2016).

The Role of Enterprise Architecture Framework for Digitalization of Cities

The concept of layered architecture was introduced to decrease complexity and structure enterprise development and evolution phase. According to ISO/IEC/IEEE 42010, an enterprise architecture refers to the basic organization and relationships of a system components, the environment, and principles governing system design and evolution (Braun & Winter, 2007; Anthony Jnr, 2021). EA is a necessary and helpful tool that helps to manage change and understand complexity within an institutional process. Hence due to the complexity associated with EA description, enterprise architecture frameworks were designed to foster the adoption of EA by practitioners (Espinosa et al., 2011; Hinkelmann et al., 2016). EAF can be defined as a logical structure for organizing and categorizing complex information. According to Borra and Iluzada (2016) and Hinkelmann et al. (2016), an EFA comprises of practices, principles, and conventions for the description of architectures institutionalized within a particular domain.

An EAF comprises of a set of graphically presented artifacts that define the services provided by the enterprise, how the enterprise operates, and what resources are required for enterprise operation. Findings from prior studies (Banaeianjahromi & Smolander, 2016; Petersen et al., 2019) stated that EAF helps to achieve faster adaptability and better complexity management, provides a comprehensive view of the enterprise, improves change management, and enhances integration and interoperability. Findings from literature (Borra & Iluzada, 2016; Toh et al., 2009) argued that EAF provides opportunity to support municipalities in managing the interrelating hardware, data, software, and communication infrastructures through a structured description of the city's information system and its relationships among the components (Banaeianjahromi & Smolander, 2016). EAF captures the deployed information systems dependencies and relationships, stakeholders involved, and corporate strategies (Barn et al., 2013; Anthony Jnr, 2021a). Traditionally EAF has been adopted for digital transformation of cities to align IT and business initiatives.

EAF provides cities with the means to manage their core challenges faced within the digitalization age by managing data interoperability, system integration, and enterprise agility (Anthony et al., 2020; Bokolo et al., 2021b). While the strategic alignment between IT and enterprise strategies generates added value to municipalities. Technological complexities that arise within urban systems impedes business IT integration and alignment (Banaeianjahromi & Smolander, 2016). In urban environment, EAF can provide an understanding of different IT and business components and depicts how these components inter-relate (Borra & Iluzada, 2016). The adoption of EAF for designing urban systems and application helps cities to achieve the interconnecting silos to streamline urban processes (Banaeianjahromi & Smolander, 2016). It supports traceability from existing institutional strategy to the underlying technological infrastructures to improve services provided by enterprises in urban environment (Toh et al., 2009).

Prior EAF Adopted to Improve Institutional Process

The adoption of EAF has been of interest for IT professionals and practitioners since 1980s (Gregor et al., 2007). Presently, there are varieties of EAF that have been employed to support institutional process to cater for the IT and business needs. Findings from the literature (Gilliland et al., 2015) mentioned that there are more than 50 EAFs designed to support enterprise process. An EAF often is a model that visualizes the relationship between the various elements in each domain. One of these is the Zachman framework proposed in 1987 for IS architecture of an enterprise. Zachman (1987) designed the IS architecture framework as the Zachman framework for EA. The Zachman framework comprises of a two-dimensional matrix of "rows" and "aspects." The row represents different perspectives of stakeholder role named (planner, builder, designer, owner, and subcontractor).

Whereas the columns capture the different enterprise aspects, the columns comprise of various abstractions to describe real-world scenarios. The aspects are based on the details of communication such as who (people), how (function), what (data), where (network), when (time), and why (motivation) constitutes the foundation for brief description of complex concepts (Gilliland et al., 2015). Although the Zachman framework does not provide prescribed processes and methods, Zachman suggested that EA should support enterprise processes and culture change (Gilliland et al., 2015). The Zachman framework has also been extensively adopted into various other EA frameworks as it provides a logical format for categorizing and organizing the IT/business components of an enterprise that are significant to the stakeholders within the enterprise (Zachman, 1987). The framework helps to illustrate how different IT/business constructs fit together, and it provides a means of viewing an enterprise system from many diverse viewpoints depicting how they are associated (Alwadain et al., 2016).

The Open Group Architecture Framework (TOGAF) is another renowned EAF, internationally considered as the defacto EAF standard (Hinkelmann et al., 2016). TOGAF was first presented in 1995 by The Open Group and has been revised over the years. It comprises of a comprehensive method which offers a set of facilitating tools for developing and managing EA adoption in institutions (Puspitasari, 2019). Findings from the literature stated that TOGAF has been proven to be an enabler for attaining the right balance between business innovation and IT proficiency (Borra & Iluzada, 2016). It has also been the most employed EAF as it provides a comprehensive approach to explain the architecture development procedure, and it can be adopted with other enterprise tools and models (Puspitasari, 2019). TOGAF comprises of a set of closely associated architectures which comprise of the business architecture, IS architecture (encompassing application architecture and data architecture), and technology architecture (Hinkelmann et al., 2016).

But, despite the availability of different comprehensive EAFs, practitioners are faced with fully adopting existing EAF into a set of practical applications in making cities smarter with limited practical guidance (Puspitasari, 2019). Likewise, many cities still struggle with adoption of EAF because of several human and IT resource and the high complexity processes involved in digitalization of urban environment. Also, the importance of inter-relationships, the elements, and the relationships among the elements of EAF is often given limited attention (Janssen, 2012). Hence, there is need for a comprehensive EAF that can capture processes, objects (stakeholders, data sources, systems, and technological infrastructures, etc.), and the related relationships which results to an extremely less complex urban eco-system.

Modeling Language and ArchiMate

Another area of EA is modeling language which describes EA from various viewpoints in detail to allow specifying and implementing the systems (Cuenca et al., 2010). A modeling language is defined by semantics, syntax, and notation that provides the required modeling objects, relationship, symbols, etc. needed to design models (Hinkelmann et al., 2016). Modeling language can help to facilitate communication between human stakeholders and clarify and show enterprise behavior by supporting the collection and representation of information needed within the enterprise (Hinkelmann et al., 2016; Toh et al., 2009). One of the modeling languages employed to model digitalization of urban environments in the literature is ArchiMate implemented based on the Unified Modeling Language (UML) as a metamodeling language, where a metamodel offers the syntax of a modeling language as they specify the available modeling components (objects, relationship, etc.) and reasonable ways to combine the components (Hinkelmann et al., 2016).

ArchiMate is an open-source independent modeling language which support enterprises in use of EA (Tanaka et al., 2018). Furthermore, ArchiMate provides an integrated language for describing EA. ArchiMate mostly fits with the TOGAF framework as it delivers concepts for designing a model that aligns to the business, information system, and technology layers of TOGAF (Bokolo et al., 2020a, b, c). According to the literature (Hinkelmann et al., 2016; Tanaka et al., 2018), ArchiMate can be employed to describe EA in a comprehensible way while tailoring IT and business components for different stakeholders. The graphical language provided by ArchiMate also helps to represent EA over time for the strategic transformation and migration planning. Also, the graphical representation employed by ArchiMate is customized to a small set of modeling constructs which is simple and easy to learn and use. Hence, in this study, ArchiMate is used as the language to document the content for digitalization of urban environment (as seen in Fig. 5).

Presented Enterprise Architecture Framework and Research Model Development

This section presents the developed EAF as well as the proposed research model grounded on the technology acceptance model.

Presented Enterprise Architecture Framework

To achieve interoperability and infrastructural flexibility towards digitalization of cities, this study presents an EAF developed by prior studies (Bokolo et al., 2020a, b, c; Petersen et al., 2019). This study differs from prior studies (Bokolo et al., 2020a, b, c; Petersen et al., 2019), as the current research is grounded in TAM and employs both qualitative and quantitative data which is not carried out in prior studies. The presented EAF is shown in Fig. 1.

Figure 1 depicts the presented EAF based on seven layers (context, service, business, application and data processing, data space, technologies, and physical infrastructures). As presented in Fig. 1, the physical infrastructure layer comprises of physical assets within the city (Berkel et al., 2018). This layer produces real-time data

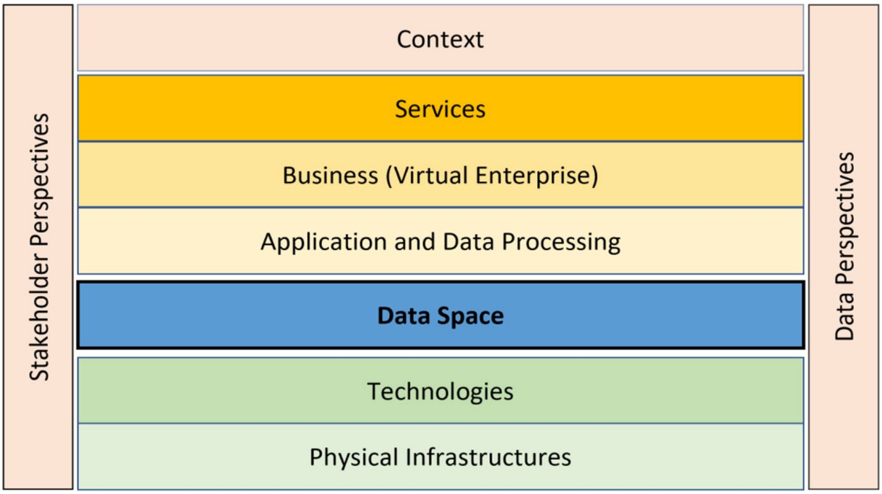

Fig. 1 Developed architecture adapted from (Bokolo et al., 2021a)

generated from physical sources that is transferred to the technology layer (Petersen et al., 2019). The physical infrastructures layer captures sensors, metering devices, IoT devices, and sensing device (e.g., smart card readers, weather sensors, Radio frequency Identification (RFID) chips tags, etc.) deployed within the city that generates real-time data (Anthony et al., 2019). The technological layer entails all the technologies deployed across the city such as ubiquitous computing, big data, processing, cloud computing, and service-oriented architecture. This layer provides the essential software and hardware infrastructures needed to provide digital services (Berkel et al., 2018). This layer consists of infrastructures needed to collect, process, handle, and temporarily store real-time data. Also, this layer deploys either cloud-based or locally run servers.

The data space layer is the intelligence of the architecture as it includes data required to facilitate digital services (Otto et al., 2018). Additionally, the data space layer specifies which data are being utilized by the city in providing digital services (Petersen et al., 2019). The data space layer captures real-time raw data from the devices and sensors, processed online data from applications deployed in cities, and analyzed historical data and lastly third-party data (for external sources) (Anthony Jnr, 2020). Moreover, data space layer contains non-relational and relational databases that support urban operations. The application and data processing layer encompass all applications deployed to provide services to citizens and stakeholders. This layer uses data from the data space layer in providing services (Anthony et al., 2019). Also, this layer processes and transforms data into useful information for digital services (Berkel et al., 2018). Hence, this layer provides application that exposes digital services to support the digitalization of urban operations (Anthony Jnr, 2020).

The business layer is responsible for capturing all partners or enterprises involved in providing functions and orchestrating processes to deliver services to citizens. Business layer involves operational activities that provide and deliver business services (Berkel et al., 2018). Accordingly, this layer involves virtual enterprises that cooperate in providing digital services to citizens to support in making city smarter (Petersen et al., 2019). The service layer is responsible for presenting the city's action plans, resources, and capabilities. It consists of high-level processes provided by the enterprises collaborating to provide new functionalities to citizens (Berkel et al., 2018). Hence, this layer aims to effectively implement specified outputs and competently realizing specified key performance goals (Anthony et al., 2019). The context layer entails requirements that relates to stakeholders' wants, concerns, and associated key performance indicators (KPIs) that improve quality of life (Bokolo et al., 2020a, b, c; Petersen et al., 2019). This layer comprises of the set of goals constraints, principles, and main requirements related to smart city initiatives (Anthony et al., 2019). The context layer also captures the interests of city stakeholders and citizens.

Furthermore, the presented EAF comprises of the stakeholder perspective and data perspectives as seen in the horizontal layers. The stakeholder perspective highlights the importance of privacy and trust, data ownership and access, policies, and regulations related to digitalization of urban environment. Similarly, the data perspective comprises of data interoperability, data standards, security, risk assessment, and data governance (Petersen et al., 2019).

Research Model and Hypotheses Development

To investigate the factors that influence users' acceptance of technology, researchers have adopted theories from social psychology and IS. Among these theories previously adopted are the technology acceptance model designed by Davis (1989), Theory of Planned Behaviour (TPB) founded by Ajzen and Fishbein (1980), and Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh et al. (2003) which are the most extensively employed theories that explore technology acceptance. TAM was developed from the Theory of Reasoned Action (TRA) by Ajzen and Fishbein (1980) by Davis (1989) to investigate users' acceptance of deployed IS. In EA context TAM has been employed to examine EA acceptance in organizations (Guo et al., 2019; Jonnagaddala et al., 2020; Lee et al., 2015; Närman et al., 2012). Thus, this study employed TAM as seen in Fig. 2. TAM was adopted to examine EA use in the digitalization of smart cities.

TAM main constructs comprise of perceived ease of use, perceived usefulness, attitude towards use, behavior intention to use, and actual system use which determines users' acceptance of technology (Bernaert et al., 2014). TAM proposed that perceived usefulness and perceived ease of use are significant constructs that influence user's attitudes toward using a particular technology (Lee et al., 2015). Additionally, in TAM, users' attitude influences behavioral intention to use an IS. EA adoption as related to technology acceptance model refers to the acceptance and adoption of EA. Hence EA acceptance described IT practitioners opt to adoption EA, and it indicates the use of EA. Besides, in urban context, there are practitioners that now adopt EA towards digitalization goal. This is because EA helps cities to achieve their urban mission on providing technical-driven services and solutions while reducing operational costs and enhancing productivity.

Therefore, in this study, the TAM is adopted to empirically validate the developed EAF as seen in Fig. 1.

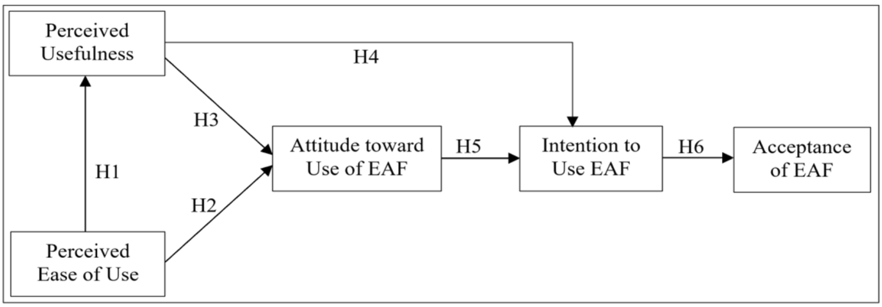

Fig. 2 Research model

Perceived Ease of Use

Perceived ease of use refers to the extent to which practitioners believes that using EAF is easy to use or require less effort to use (Närman et al., 2012). It is the user's perception that using EAF will be reasonably free of cognitive problem and also measures the capability with which practitioners are able to easily integrate EAF (Jonnagaddala et al., 2020). Davis (1989) stated that user perceives that if the use of new technology is difficult to use, the users are likely to look for other substitutes or may revert to familiar approaches. Thus, practitioners would be more willing to use EAF, if they observe that it is easy to be used (Grover et al., 2019). Findings from the literature (Jonnagaddala et al., 2020) suggested that perceived ease of use has a positive influence on practitioner's attitude and perceived usefulness. Therefore, this study proposes the following hypotheses:

H1: Perceived ease of use of the EAF will positively influence perceived usefulness of EAF for digitalization of smart cities.
H2: Perceived ease of use of EAF will positively influence practitioners' attitude towards using EAF for digitalization of smart cities.

Perceived Usefulness

In this study, the perceived ease of use is defined as the degree to which the user believes that using EAF approaches will be effortless (Lee et al., 2015). Perceived usefulness refers to practitioners' perception that EAF will be useful in improving digitalization in urban environment (Närman et al., 2012). Findings from recent studies (Grover et al., 2019; Jonnagaddala et al., 2020) reported that the perceived usefulness of using EAF was significantly determined by the overall practitioners' attitude toward use and intention to continue using EAF in digitalization process. Moreover, findings from prior EA research (Bernaert et al., 2014) confirmed that perceived usefulness is a critical factor that predicts the use and acceptance of IS. Based on the aforementioned observations, the following hypotheses are proposed:

H3: Perceived usefulness of EAF will positively influence practitioners' attitude towards using EAF for digitalization of smart cities.
H4: Perceived usefulness of EAF will positively influence practitioners' intention to use EAF for digitalization of smart cities.

Attitude Towards the Use of EAF

Attitude refers to practitioners positive or negative evaluative opinions about implementing a specific behavior (Davis, 1989). Thus, practitioners' attitude towards using EAF is an essential determinant that influences their intention to use EAF to improve urban digitalization experience (Gilliland et al., 2015). Practitioners who have positive attitudes toward IT usage for improving city services are more willing to use EAF. Where findings from prior studies (Hazen et al., 2014) reported that practitioners who have positive attitude toward EA may motivate and encourage their peers to use it, apparently, attitude influences the behavioral intention suggesting that a positive attitude will significantly influence practitioner's intention to use EAF (Närman et al., 2012). Thus, this study hypothesized the following:

H5: Practitioners' attitude towards using EAF will positively influence their intention to use EAF for digitalization of smart cities.

Intention to Use EAF

In this study, intention is defined as the prospect that practitioners will use EAF in their urban digitalization process (Davis, 1989). Moreover, intention to use refers to the decision and interest of practitioners to use EAF before they actually use it and it is mostly predicted to occur in future (Lange et al., 2016). Researchers such as Närman et al. (2012); Lee et al. (2015) examined the relationship between intention and actual use in EA and argued that intention plays an important role in the actual use of EA in organizations. This finding is analogous with results from Jonnagaddala et al. (2020) where the authors found that stakeholders who have a strong intention to use IT would adopt EA more regularly for digitalization of health services. Moreover, Gilliland et al. (2015) argued that when practitioners perceived EA to be useful they are more interested to adopt it in their enterprise process. This results to a direct impact on their intention to use EAF. Based on this, the following hypothesis is formed:

H6: Practitioners' intention to use EAF will positively influence their acceptance of EAF for digitalization of smart cities.

Acceptance of EAF

In this study acceptance refers to the extent of cognitive spontaneity of practitioner's interactions with EAF. Acceptance is considered influenced by the intrinsic belief of the user which is centered on prior experiences with EA. Acceptance represents the inherent motivation related with using EAF which significantly influences the urban digitalization performance.

Based on TAM adopted in this study, the research model is developed as seen in Fig. 2.

Figure 2 depicts the research model developed to examine the factors that influence the acceptance of EAF by practitioners in urban environment. The model is employed to validate the developed EAF (see Fig. 1).

Methodology

A mixed-mode methodology was employed as recommended in the literature (Börkan, 2010; DeLeeuw, 2018), to gain more insight on the phenomenon being investigated as shown in Fig. 3.

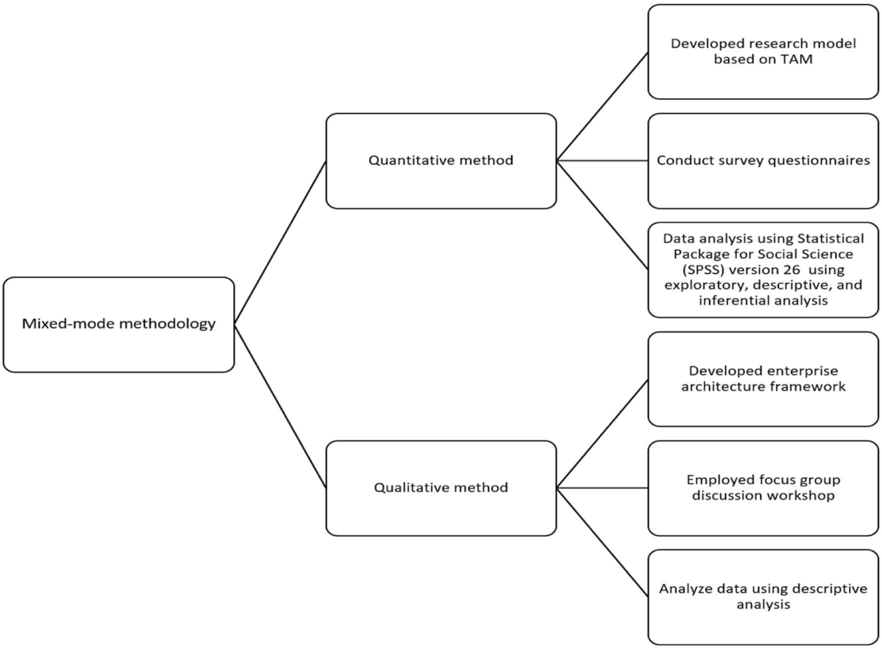

Fig. 3 Methodology adopted in the study

Figure 3 depicts the mixed-mode methodology employed in this study. This research approach helps researchers to reflect respondents' point of view as it provides a medium to examine participants and confirm that research findings are justified in participants' experiences, although it can be much complex to carryout mixed methods as it may involve more knowledge to collect both qualitative and quantitative data. Moreover, more time is needed to analyze and interpret data from mixed-mode data which may require extra resources, such as finance and time (Börkan, 2010; DeLeeuw, 2018). But overall, mixed methods are particularly valuable in understanding disagreements between qualitative and quantitative results findings. Thus, it was adopted in this study. Quantitative data was collected via survey questionnaires, and qualitative data was collected via focus group workshop with participants that utilize the developed EAF to provide digital services in smart cities.

Study Context

This study comprises of enterprises in Norway and Ireland involved in a sustainable smart city project (+CityxChange) (https://cityxchange.eu/)). The+CityxChange smart city project aims to facilitate the co-creation of a future for municipalities to integrate renewable energy solutions. This is achieved through deployment of digital solutions to improve the quality-of-life citizens, improving energy production and lower energy consumption, and providing recommendation towards experiences to cities across Europe and the world. Most participants were familiar with EA. Focusing on experienced consultants, researchers, IT professionals, and senior managers who had experience in adopting EA in smart city environment.

Quantitative Data Design

To validate the developed EAF based on the research model (see Fig. 2), a cross-sectional survey questionnaire was designed targeting practitioners and stakeholders who use the developed EAF (see Fig. 1) for digitalization of smart cities similar to prior study (Bokolo et al., 2021b). The questionnaire was developed in English language. This method was employed based on EA research that relies on quantitative data and the need for an urban level research model grounded on practice-oriented ideas that deliver meaningful insights. In developing the questionnaire measures, potential items were identified from prior EA studies that adopted TAM as presented in Table 1. The data was collected from practitioners in 18 enterprises based in Ireland and Norway involved in a smart city project. The practitioners provided data regarding their perception and acceptance of the developed EAF. Purposive sampling technique was employed targeting practitioners, and researchers who had knowledge in adopting EA or are conversant with EAF adoption mainly in smart city context. The responses from the respondents provide data for validating the developed EAF.

Quantitative Data Collection Procedure

The data was collected from November 2020 to January 2021. The first invitations were sent in November 2020 to prospective respondents to participate in the survey. Then after sending the initial invitation, a follow-up message was sent as reminders to improve the response rate in January 2021. The questionnaire comprises of three main sections. The first section introduces the respondents to the need for the survey. The second section includes demographic information of the respondents (gender, age, organization type, type of services primarily provided, primary role, years of experience with EA, and familiarity with the developed EAF), employing ordinal scale as presented in Table 2. The third section of the questionnaire rates the respondent's perception towards the use of EAF in digitalization of smart cities measured based on a 5-point Likert scale ranging from strongly disagree to strongly agree. The questionnaire items are presented in Table 1.

Results

Results from Quantitative Data Analysis

To analyze the survey data, Statistical Package for Social Science (SPSS) version 26 was used to carryout exploratory, descriptive, and inferential analysis.

Table 1 Questionnaire items

Factors	Items	Sources
Perceived ease of use	PE1-The developed EAF is relevant for my work	(Lee et al., 2015; Grover et al., 2019)
	PE2- The developed EAF is relevant for the + CxC smart city project	
	PE3- The developed EAF is useful for my work	
	PE4- The developed EAF is useful for CxC smart city project	
Perceived usefulness	PU1- The developed EAF is easy to understand	(Närman et al., 2012; Gilliland et al., 2015)
	PU2- The developed EAF is easy to use	
	PU3-The use case models designed in the developed EAF are easy to understand	
	PU4-I find it easy to describe a scenario using the use case models within the developed EAF	
Attitude towards the use of EAF	AT1- I feel the developed EAF could help in discussions with colleagues and/or collaboration with partners within my organization	(Bernaert et al., 2014; Grover et al., 2019; Jonnagaddala et al., 2020)
	AT2- I feel the developed EAF could help when explaining use cases and solution architectures to colleagues	
	AT3- I feel the developed EAF could help with capturing knowledge	
	AT4- I feel the developed EAF could help with sharing knowledge within my organization and/or project partners	
	AT5- I feel the developed EAF could help when sharing knowledge across cities	
	AT6- I feel the developed EAF could help with reusing knowledge	
Intention to use EAF	IT1-I will recommend the developed EAF to colleagues in my organization	(Bernaert et al., 2014; Jonnagaddala et al., 2020)
	IT2-I will use developed EAF for my work in the future	
	IT3-I will use the use case models designed in the developed EAF for my work in the future	
	IT4-I will recommend the use case models designed in developed EAF to colleagues in my organization	

Table 1 (continued)

Factors	Items	Sources
Acceptance of EAF	AC1-I agree that the use case models designed in developed EAF are useful for my work	(Authors own)
	AC2- I agree that the use case models designed in developed EAF are useful for the + CxC smart city project	
	AC3- I agree that the use case models designed in developed EAF have helped me clarify details about use cases of digital services provided my organization	

+CxC = +CityxChange smart city project (https://cityxchange.eu/)

Table 2 Demographic characteristics of the survey respondents

Profile	Options	Percentage
Gender	Male	92.7
	Female	7.7
Age	20–30 years	30.8
	31–40 years	23.1
	41–50 years	38.5
	51–60 years	7.7
Type of organization	University	23.1
	Research organization	15.4
	City council or municipality	7.7
	Private organization	53.8
Type of services organization mainly provides	Energy related	7.7
	Data related	23.1
	Innovation related	23.1
	ICT Infrastructure related	15.4
	Other	30.8
Experience with using EAF	Just knew about EA recently	30.8
	Less than 1 year	38.5
	1–3 years	23.1
	4–5 years	7.7
Experience with smart city projects	Just knew about smart city recently	7.7
	1–3 years	76.9
	4–5 years	15.4
Familiarity with the developed EAF	I have seen a presentation of the developed EAF	38.5
	I have provided feedback for the developed EAF	23.1
	I have provided input and/or feedback to one or more models based on the developed EAF	30.8
	I am not familiar with the developed EAF	7.7

Demographic Analysis

The demographic characteristics of the respondents are shown in Table 2.

Findings from Table 2 suggest that most of the respondents are male and are between the age of 41 and 50 years. Also, 53.8% of the respondents work in private organizations and 30.8% of the respondents' organizations provide "other smart city"-related services such as public services (housing, roads, environmental, water, etc.), economics, planning, and data analytics towards digitalization of urban environment. Regarding their experience with using EAF, 38.5% of the respondents have less than 1 year and 30.8% just knew about EA recently. With respect to the respondents' experience with smart city projects, 76.9% of the respondents have up to 1–3 years' experience. Lastly, 38.5% have seen a presentation of the EAF, 23.1% have provided feedback, 30.8% have provided input and/or feedback to one or more designed models based on the EAF, and lastly 7.7% are familiar with the developed EAF.

Descriptive Analysis

Descriptive analysis aims to accurately describe the factors under study within a detailed sample. The descriptive analysis is measured based on the mean and standard deviation score of the research model constructs. The mean values of all constructs should be higher than 2.5, and the standard deviation value should be closer to 1 showing that the data responses are close and not extensively dispersed. Results from Table 3 show that the mean and standard deviation values are within the required range. Next the test of normality was carried out by measuring the Skewness and Kurtosis values, where the suggested cutoffs of 3.0 for Skewness and 8.0 for Kurtosis are satisfactory as recommended by Bokolo et al. (2020a, b, c).

Results from Table 3 depict the mean value based on the 5-point Likert Scale (1–5), response from the participants. For mean score, 1 = least important, 2 = fairly important, 3 = important, 4 = very important, and 5 = most important. Results from Table 3

Table 3 Descriptive analysis

Constructs	Items	Mean	Standard deviation	Skewness	Kurtosis
Perceived ease of use	PE1	3.69	0.947	0.037	−0.818
	PE2	4.23	0.832	−0.498	−1.339
	PE3	3.38	0.650	−0.572	−0.332
	PE4	4.08	0.641	−0.053	0.061
Perceived usefulness	PU1	3.31	0.630	−0.307	−0.317
	PU2	3.00	1.080	−1.876	4.784
	PU3	3.38	0.650	−0.572	−0.332
	PU4	3.15	1.144	−1.929	4.441
Attitude towards the use of EAF	AT1	3.85	0.689	−1.605	4.594
	AT2	3.92	0.641	0.053	0.061
	AT3	3.69	0.751	−0.784	1.223
	AT4	3.92	0.760	−1.213	3.154
	AT5	4.08	0.494	0.262	2.573
	AT6	4.08	0.494	0.262	2.573
Intention to use EAF	IT1	3.15	1.068	−2.292	6.822
	IT2	2.92	1.038	−1.940	5.318
	IT3	3.08	1.038	−2.290	7.074
	IT4	3.46	0.519	0.175	−2.364
Acceptance of EAF	AC1	3.38	1.193	−1.940	5.537
	AC2	3.92	0.494	−0.262	2.573
	AC3	3.69	0.630	0.307	−0.317

show that all item mean scores are higher than 3.00 which assess the significant criteria to rate respondents' perception towards each factor that influences practitioner's acceptance of the developed EAF for digitalization of urban environment. Additionally, Table 3 indicates that the standard deviation values of the items are not too far from 1 suggesting that the response from the participants are mostly similar. The results from Table 3 also show that for Skewness and Kurtosis, all values are between the stipulated benchmark (lower than 3.00 for Skewness and also lower than 8.00 for Kurtosis).

Exploratory Analysis

Exploratory analysis is carried out on the survey data to test how statistically significant are the questionnaire item. In addition, exploratory analysis aids to establish the questionnaire items that impacts respondents' perception towards use of the developed EAF. Hence, for exploratory analysis, tests of reliability and validity are carried out. Reliability measures the internal consistency of the questionnaire items related to each factor in the research model assessed by checking the Cronbach's alpha α. Accordingly, the Cronbach's α reliability coefficient should be higher than or equal to 0.7 as suggested by Cronbach (1951) and Hair et al. (2006). Additionally, in exploratory analysis, assessment of the factor loadings, Kaiser–Meyer–Olkin (KMO) test of sampling adequacy approximate Chi-Square $\chi 2$, and Bartlett's test of Sphericity (*p-value*) were tested as recommended by Ozkan and Koseler (2009) and Bokolo (2021b) to evaluate the reliability of the research model factors. Accordingly, KMO scores around 0.5 are barely adequate, and greater KMO values are characterized as average (0.5–0.7), acceptable (0.7–0.8), great (0.8–0.9), and excellent (above 0.9).

Results from Table 4 suggest that Cronbach's α reliability coefficient is equal or approximately 0.7. Also, results from Table 4 depict the KMO and Barlett's test score derived from the factor analysis test conducted in SPSS showing that the KMO values are higher within the 0.5 limit, hence showing that the items are slightly valid at a significance of 0.026 with acceptance of EAF and 0.000 for the other factors. Furthermore, the Bartlett's test of sphericity $\chi 2$ (35.873, 27.966, 40.480, 27.427, 4.963), at $p < 0.000$, demonstrates that the items are reliable to proceed for hypotheses testing. Next, validity was evaluated based on the correlation coefficient or Pearson correlation coefficient (r) (Anthony Jnr, 2021a, 2021b). As recommended by Cohen et al. (2014), the correlation coefficient which ranges from 0.1 to 0.29 denotes weak coefficient, 0.30 to 0.49 is average coefficient, and 0.50 to 1.0 denotes strong coefficient. Besides, the Pearson correlation coefficient should be between − 1 and + 1. Results from Table 4 show that the Pearson correlation coefficient for the factors (perceived ease of use, perceived usefulness, attitude towards use of EAF, and intention to use EAF in relation to acceptance of EAF) ranges from 0.243, 0.263, 0.363, and 0.385. This suggests a weak and average correlation. These results confirm that the data is valid for hypothesis testing, although the correlation is weak mainly due to limited samples employed in this study.

Table 4 Exploratory statistical analysis

Constructs	Items	Factor loading	Cronbach's alpha (α)	KMO	Approx. Chi-Square $\chi 2$	Pearson correlation coefficient (r)	Bartlett's test of sphericity (p *value*)
Perceived ease of use	PE1	0.723	0.867	0.561	35.873	0.243	0.000
	PE2	0.891					
	PE3	0.970					
	PE4	0.856					
Perceived usefulness	PU1	0.855	0.758	0.500	27.966	0.363	0.000
	PU2	0.896					
	PU3	0.744					
	PU4	0.940					
Attitude towards the use of EAF	AT1	0.849	0.891	0.543	40.480	0.263	0.000
	AT2	0.777					
	AT3	0.859					
	AT4	0.870					
	AT5	0.868					
	AT6	0.868					
Intention to use EAF	IT1	0.972	0.700	0.500	27.427	0.385	0.000
	IT2	0.937					
	IT3	0.978					
	IT4	0.776					
Acceptance of EAF	AC1	0.979	0.700	0.500	4.963	1.00	0.026
	AC2	0.720					
	AC3	0.857					

Inferential Analysis (Model Validation)

Inferential analysis supports researchers to make decisions on the observed difference between variables and also helps to explain the meaning of data. Additionally, inferential analysis investigates the relationship between the constructs. The validation of the model hypotheses was tested via regression analysis using SPSS. Regression analysis is employed as it is versatile and flexible in revealing quantitative dependency among factors (Bokolo, 2019).

For regression test, the *p* significant value, f-*test*, R^2, path coefficient (β), effect size measure (*t-value*), and *standard error* were employed to confirm or reject a hypothesis as presented in Table 5. Results from Table 5 and Fig. 4 represent the inferential analysis using regression analysis for the model hypotheses. The strength of relationships is also assessed by checking the R^2 value of the factors. The R^2 value of the attitude towards use of EAF, intention to use EAF, and acceptance of EAF is only reported as these variables have direct effect from other variables within the model. The results indicate that intention to use influences the acceptance of EAF by practitioners in digitalization of smart cities at $R^2 = 0.148$ (14.8%) of the variance. Next, is perceived usefulness influence on practitioner's intention to use EAF with $R^2 = 0.072$ interpreting at 7.2% of the variance. Lastly, the impact of attitude towards the use of EAF has an $R^2 = 0.004$ interpreting at 0.4% of the variance of intention to use EAF.

Furthermore, all the model factors have a direct path coefficient as revealed by the positive beta result ($\beta = 0.048$, 0.184, 0.206, 0.268, 0.062, 0.385), which represents the relative significance of the factors (see Table 5). Additionally, by assessing the *t test* value of all factors, the results suggest that the values are greater than 1.96 benchmark (4.249, 4.747, 3.619, 3.602, 2.230, 3.223) as recommended by Hair et al. (2006), indicating that the model hypotheses H1–H6 are significantly supported. Besides, considering the *p value* is lower than the significance level $p = 0.05$ for all hypothesized path (0.001, 0.001, 0.004, 0.004, 0.048, and 0.008), therefore, confirms the hypotheses (H1-H6). These results suggests that H2 has the highest *t value* with 4.747 which states that the perceived ease of use of EAF positively influences practitioners' attitude towards the use of EAF, followed by H3 with *t value* = 4.249 stating that perceived ease of use of EAF significantly influences perceived usefulness of EAF. These results reveal that if practitioners perceive EAF to be ease of use, then they will adopt EAF for digitalization of urban services.

Qualitative Data Design and Procedure

A qualitative research approach was also adopted for this study analogous to prior study (Gregor et al., 2007). This approach allowed data to be collected across multiple different sources such as from document review, observation, and interview (Bokolo et al., 2020a, b, c). The qualitative data is collected to validate the developed EAF layers as presented in Fig. 1. Accordingly, focus group discussion workshop was carried out with 4 participants (see Table 6), in an organization based in Ireland that utilize the developed EAF to provide digital services in smart cities.

Table 5 Inferential analysis (hypothesis testing)

Relationships		**Regression analysis**				
Hypothesis path	**Hypotheses**	**Path coefficients (*β*)**	**Standard error**	***t*-test**	***p* value (Sig.)**	**Decision**
Perceived ease of use perceived usefulness	H1	0.048	0.287	4.249	0.001	Supported
Perceived ease of use attitude towards the use of EAF	H2	0.184	0.223	4.747	0.001	Supported
Perceived usefulness attitude towards the use of EAF	H3	0.206	0.234	3.619	0.004	Supported
Perceived usefulness intention to use EAF	H4	0.268	0.301	3.602	0.004	Supported
Attitude towards the use of EAF intention to use EAF	H5	0.062	0.393	2.230	0.048	Supported
Intention to use EAFAcceptance of EAF	H6	0.385	0.249	3.223	0.008	Supported

Decision: Hypothesis is valid if *t value* = > 1.96 and *p value* = < 0.05

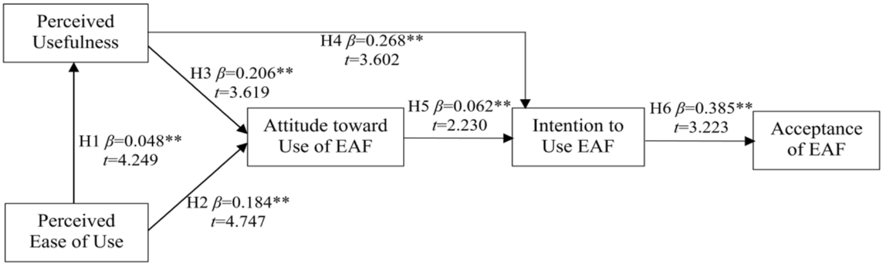

Fig. 4 Results of the research model validation

During the focus group workshop which lasted for more than 2 h in duration, the developed EAF was demonstrated to the participants.

Then, one of the participants in the focus group workshop explained the role of a digital platform being implemented to support monitoring and evaluation in smart city for the + CityxChange project. Next, use case model of the monitoring and evaluation platform implemented by the organization was captured in the developed EAF to illustrate the importance of the EAF to the participants. Then, during the focus group discussion, qualitative data was collected as feedbacks from the participants on each of the EAF layers, components, and relationships.

Results from Qualitative Data Analysis

Background of Case study

In this study, the participants involved in the focus group belong to an organization. For confidentiality purposes, the organization is termed as "Organization A" which is based in Ireland that focuses on helping public and private sectors achieve a sustainable future. "Organization A" is concerned with addressing climate changes and sustainability issues which have currently reached a tipping point. According to the enterprise beliefs, corporate social responsibility should be seen as a strategic issue for enterprises. The organization comprises of team of experts who aids private and public sector to plan and implement initiatives geared towards addressing governance, social, decarbonization, and environmental challenges for long-term value creation. "Organization A" has practitioners in different areas such as in sustainable urban planning and design to help clients and stakeholders navigate climate change and sustainability issues. The organizations provide strategies and knowledge to promote corporate reporting and assurance circular economy, sustainability monitoring, and assessment of technology adoption.

Organization A is responsible in providing monitoring and evaluation services to improve digital services for smart city development. Participants in "Organization A" involved in a smart city project were invited to provide qualitative data to validate the developed EAF layers (context, service, business, application

Table 6 Overview of participants

#	Current position	Education	Years of experience	Current role and responsibilities
1	Associate director	PhD	Above 10 years	•Focus on the social effect in the areas of social security, sustainable city, and urban resilience •Carryout research and documents qualitative report on projects
2	Managing director	PhD	Above 20 years	•Offers expert advice to cities on strategic spatial planning and development •Provides forecasting and economic analysis for cities towards urban resilience, infrastructure planning, and impact assessment
3	Senior consultant	BSc	Above 7 years	•Involved in geographic information system, data analytics, and research in urban domain •Provides research and data driven projects for assessment on sustainable urban attainment
4	Software development manager	MSc	Above 8 years	•Responsible for development of digital platforms and applications in urban context •Collects and manages city data for storage and decision-making analysis for citizens and other stakeholders in urban environment

and data processing, data space, technologies, and physical infrastructures) presented in Fig. 1.

Qualitative Data of Participants

Table 6 depicts the participants involved in providing qualitative data related to improving digitization of smart cities. The current position, educational qualifications, years of experience, and current role and responsibility are presented.

Table 6 shows that qualitative data was collected from four participants involved in focus group workshop as recommended by Yin (2013) where the author suggested that qualitative data should be collected from more than three participants from an organization. The focus group questions were based on the usefulness of the 7 layers of the developed enterprise architecture framework as shown in Fig. 1. The feedback from the interview was modeled in ArchiMate modeling tool as seen in the next section.

ArchiMate Modeling of a Use Case in the Developed EAF

Qualitative data was provided based on a monitoring and evaluation platform the organization implemented to monitor digital services and sustainability goals archived in two cities in Ireland and Norway. The collected data as feedback was directly modeled in ArchiMate language during the workshop session. After several iterations during the focus group workshop, a final model was approved by all participants in the workshop. The revised use case modeled in the developed EAF is shown in Fig. 5.

Findings from the focus group session is modeled in ArchiMate language as seen in Fig. 5 which illustrates a use case for monitoring and evaluation platform implemented in "Organization A" to facilitate the digitalization of smart cities.

The metamodeling of the case scenario seen in Fig. 5 illustrates an established methodology for Monitoring and Evaluation Reporting Tool (MERT) of + CityxChange smart city project, showing how data is collected across the project infrastructures. The MERT provides a dashboard that aims to ensure reliable and accurate data analysis for the + CityxChange project. Findings as depicted in Fig. 5 highlight that the MERT provides generated data to be monitored on online data collection systems, using IoT sensors, surveying, and other data monitoring mechanisms applicable in urban context. The data generated from MERT system stimulates wider data dissemination via dashboard and further reports some KPI data to the European Union (EU) Smart Cities Information System (SCIS) Self-Reporting Tool (SRT) for benchmarking with other smart city projects.

The findings suggest that all layers (context, service, business, application and data processing, data space, technologies, and physical infrastructures) in the developed EAF are important as seen in Fig. 5. Respectively, the findings show that physical infrastructure layer captures the entire smart city which entails both physical and virtual locations where physical communication devices and facilities are deployed to facilitate digitalization of smart cities. Likewise, the technology

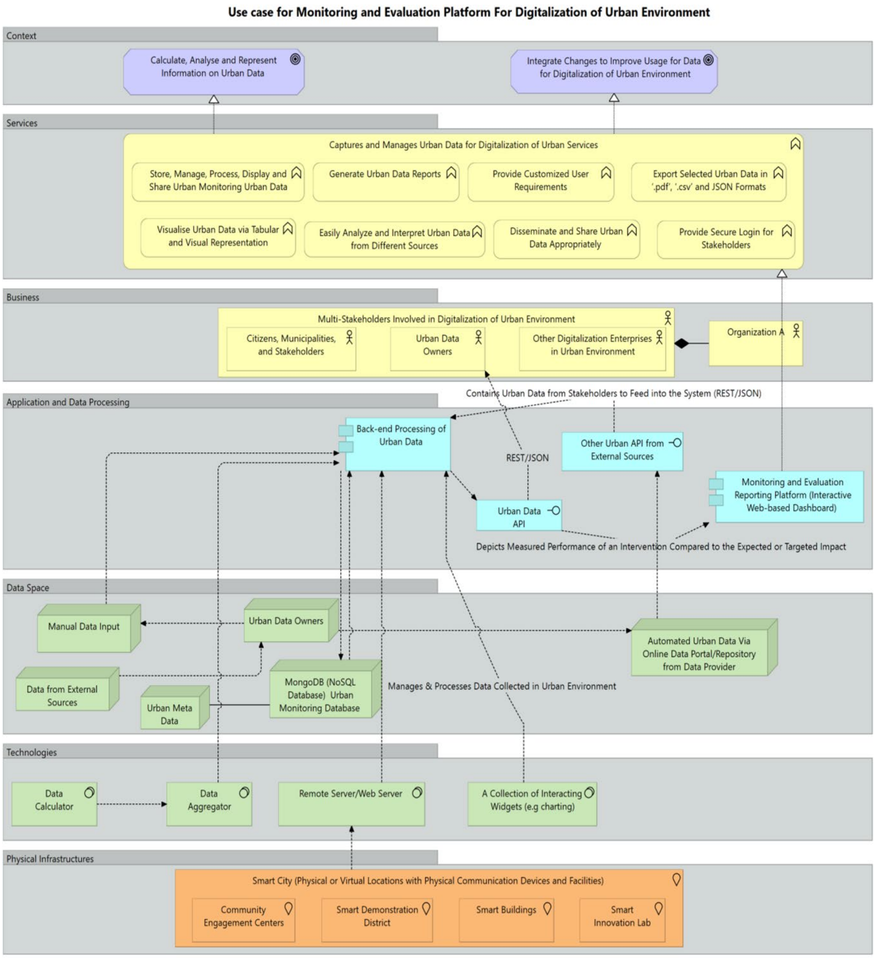

Fig. 5 Metamodeling of the monitoring and evaluation platform

layer comprises of both hardware and software deployed to support digitalization in urban settings. This layer captures technologies such as data calculator, data aggregator, remote server/web server, and widgets which provide data to citizens. The data space layer captures all data sources which provides data need for digitalization of urban services such as MongoDB (NoSQL Database) for urban monitoring.

All urban-related data are collected, processed, and saved in this layer in different databases. The application and data processing comprise of systems and application programming interfaces (APIs) which provide access to databases. All systems deployed to support digitalization services to citizens and stakeholders are captured in this layer as seen in Fig. 5. Such systems comprise of back-end processing of urban data, the monitoring and evaluation reporting platform which is an interactive web-based dashboard used by different users of the implement digitalized urban platform to support monitoring and evaluation in smart city. Data can be submitted into the MERT via a manual process (inputting data via the online key performance indicator (KPI) interface of the MERT) or through an automatic process for sharing urban data between other stakeholders through API connection.

The business layer comprises of all stakeholders involved in the digitalization process within the city, and service layer comprises of different urban data for digitalization of urban services provided to improve the economic, social, and environment goal of the city`s residents. Finally, the context layer captures the main goal which includes calculating, analyzing, and representing information on urban data and integrates changes to improve usage for data towards digitalization of urban environment. The context to be achieved is based on all the individual services provided by the monitoring and evaluation platform for digitalization of smart cities.

Overall, findings from the qualitative study present the use case scenario and the monitoring and evaluation platform developed in the sustainable smart city project (+CityxChange). The MERT was developed by one of the partners in the +CityXChange project. The MERT aims to process, display, manage, store, and contribute to smart city monitoring of data. The MERT was implemented as an interactive online-based dashboard to evaluate and analyze urban data. The MERT contributes to the actualization of an ICT ecosystem for the smart city project to provide a repository for monitoring urban data captured by KPI and urban data owners, from where the data is represented and made available for dissemination to other stakeholders towards the digitalization of the city.

Discussion

Insights from Qualitative Data

Enterprise architecture is defined as a discipline that holistically and proactively leads organizational response to disruptive technologies by specifying and analyzing the deployment of changes such as digitalization towards anticipated enterprise vision and goal. Findings from the qualitative data is in line with prior study (Barn et al., 2013) suggesting that the developed EA aims to provide a holistic understanding of all areas of a city, connecting the associated business processes with the organizational units, stakeholders' roles, and responsibilities to the underlying IT components needed for digitalization of smart cities. As stated by Banaeianjahromi and Smolander (2016), EA aligns IT strategy and business goals towards data integration to improve information sharing across the enterprise. Findings from the literature stated that EA is mainly systematized using enterprise architecture frameworks (EAFs) (Romero & Vernadat, 2016). As seen in Fig. 5, the developed EAF provides a logical structure for organizing and classifying the descriptive illustrations of a digital services provided to improve smart city`s process.

Additionally, findings from the qualitative data confirm all the seven layers (context, service, business, application and data processing, data space, technologies, and physical infrastructures) of the developed EAF. Thus, the findings depict that the developed EAF describes both the present “as-is” and future “to-be” states of smart cities. The developed EAF also simplifies the digitalization goals of cities, since it aids to articulate how the different ICT components deployed within the city relate to one another. Additionally, as recommended by Cuenca et al. (2010), the EAF developed in this study provides a general mechanism for defining views which reduce complexity associated in digitalization of urban services making it feasible for enterprises to collaborate and provide digital services to citizens and stakeholders.

Empirical Evidence from Quantitative Data

Quantitative data was collected using survey questionnaires and analyzed using SPSS for descriptive, exploratory, and inferential analysis. The results from this study support the conclusion made by Davis (1989) and Närman et al. (2012) that perceived ease of use significantly influences perceived usefulness of EAF. This result seems quite reasonable since perceived ease of use of EAF relates to the degree to which practitioners expect that EAF deployment will be free of difficulty during adoption (Lee et al., 2015). Also, in accordance with Närman et al. (2012) and Bernaert et al. (2014), the results suggest that the perceived ease of use has a direct effect on practitioners’ attitude towards the use of EAF for improving digitalization of smart cities. This result is also in line with findings from Jonnagaddala et al. (2020), where the authors found that the easiness of EAF influences the use of EA to develop digital health services.

Furthermore, the results suggest that the perceived usefulness of EAF has a positive impact on practitioners’ attitude towards using EAF for digitalization of urban environment. This result is similar to findings from Närman et al. (2012) where the authors established that the perceived usefulness significantly influences IT professional attitude and intention towards the use of applications. Accordingly, the greater the perceived usefulness of EAF, the more significant is practitioners’ attitude and intention towards usage, hence greater the prospect that EAF will be adopted (Lee et al., 2015). Another notable finding of the study is that the perceived usefulness of EAF has a positive effect on practitioners’ intention to use EAF. A possible interpretation is that the perceived usefulness assesses the extent to which a user believes that organizational activities will be enhanced by adopting EAF (Bernaert et al., 2014). Likewise, findings from previous studies (Jonnagaddala et al., 2020) revealed that the perceived usefulness significantly specifies the extent to which practitioners believe that using EAF would improve digital health services.

Another interesting observation relates to the effect of practitioner’s attitude towards their intention to use EAF, where the results confirm this hypothesis. One possible explanation is that the attitude is based on the practitioner’s experiences which may be negative or positive feelings encountered in using EAF for modeling of digital services provided to citizens in urban context. This result is similar to findings from prior studies (Gilliland et al., 2015; Hazen et al., 2014), where their results suggested that the attitude of staffs is an important factor that influences EA adoption as it entails not only the value, understanding, and knowledge of technology but also user ability to use EA. In this study, practitioner's intention to use EAF is found to be a significant factor that influences their acceptance of EAF to be used for digitalization of smart cities. This result is consistent with the studies undertaken by Närman et al. (2012) and Lee et al. (2015) where the authors highlighted that intention to use embodies the extent and manner in which EA is utilized by practitioners in their organizational process.

Conclusion and Implications

Research and Practical Implications

Presently, there are fewer studies that explore EA adoption aimed at supporting the digitalization of urban environment. In this study EAF is suggested to help allocate resources and structure priorities to achieve a smart city. Also, EAF creates a blueprint of both the present and target IS and data to support urban activities. Additionally, this study provides important insight into various factors that impacts EA implementation in urban context. The results of this research also contribute to future EA studies by proposing a research model based on TAM to investigate the adoption of enterprise architecture framework towards the digitalization of urban environment. The findings also contribute to theory by providing practitioners and researchers with knowledge on the potential factors contributing to EA adoption from the lens of practitioners involved in digitalization of smart cities.

A questionnaire was designed that highlighted a number of important items (see Table 1) that can be considered to ensure successful EAF adoption by practitioners in making cities smarter. The items can be used as an assessment tool to evaluate EA usage for enterprises with a low EA adoption. Data collected from a focus group workshop provides evidence that guides the design and future evolution of urban digitalization. Evidence from the qualitative data can help cities to plans and make decisions on the factors that impact or enhance the current state of EA adoption. The findings from this study were discussed from a theoretical (based on the designed research model grounded on TAM) and a practical perspective (based on the developed EAF) including a modeled use case in ArchiMate (see Fig. 5), to provide recommendations for action, thus providing better understanding of the potential of capabilities of EAF in improving the digitalization of cities.

Summary, Limitations, and Future Direction

Cities are faced with aligning IT and business strategies to achieve urban digitalization. Therefore, the purpose of the study is to present an enterprise architecture framework as a tool to advance city's digitalization goal in creating coherence and improving interoperability of urban information systems. Theoretically, this study develops a research model grounded on TAM to examine the factors that influence the acceptance of the developed EAF by practitioners in urban environment. Thus, TAM is employed in this study as a theoretical base as it provides an explanation of the factors that influence the acceptance of EAF and can describe practitioner's behavior. Besides, survey questionnaires were employed to gather data from practitioners in organizations that currently adopt EAF in a smart city project to empirically validate the developed EAF. Also, the developed enterprise architecture framework layers were validated through a focus group workshop with 4 participants that utilize the developed EAF to provide digital services.

Practically, findings from this study will help to provide more insights on the usefulness of the developed EAF. Socially, findings from this study suggest that cities should not neglect the capabilities of EA but should rather improve adoption of EAF to improve their digitalization goals. More importantly, this current study contributes to the existing body of knowledge on EA adoption in smart city context by designing a model that comprises of factors from TAM and by using this collection of factors to design a questionnaire instrument (see Table 1) to validate the developed EAF. As related to limitations of the study, this research is based on data collected from Ireland and Norway. Further, this study collected data from enterprises that had already used the developed EAF, and no data was not collected from non-adopters of the EAF. Therefore, findings from this study should be confined to countries with similar digitalized smart city settings. Future works will involve collecting more quantitative and qualitative data from practitioners in different cities who are digitalizing their city services to further validate the developed EAF. Additionally, other technology acceptance theories such as IS success model, UTAUT, Diffusion of Innovation (DoI), etc. can be employed to investigate EA adoption in improving digitalization of urban smart cities.

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