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IT Maturity Model Design and Evaluation for Sustainable Smart Cities Assessment

Ehab J. Adwan [1)*]

[1)] *University of Bahrain, College of Information Technology, Sakhir, Bahrain*
[1)] eadwan@uob.edu.bh

Abstract

Background: The Economic Vision for sustainable smart cities (SSC) necessitates a continuous monitoring tool that assesses the long-term planning progress of the Economic maturity level (ML) which is dependent on the Maturity Models (MM) of the Enabling Technology/ICT capabilities as its analyzes, measures the maturity levels (ML) of Smart Cities (SCs), and assesses the Economic ML of the SSCs. Recent MM have several shortcomings such that they are: 1) undedicated and overlapping the SC domains, 2) missing details of SC cases, 3) applying indicators from ambiguous databases, 4) unable to identify SC baseline, 5) lacking easiness, usefulness, decision support, comprehensiveness, timeliness, and usage intention, and/or 6) not targeting the Economic dimension of SSC.
Objective: Aiming at monitoring the long-term planning progress of the SSC's Economic maturity level (ML), this study developed and evaluated an Enterprise Architectural (EA) MM tool (BSSC-ML) that is capable to continuously assess the SC's transition from AS-IS (SC) to TO-BE (SSC's Economic MLs) by analyzing the Enabling Technology/ICT capabilities, 2) measuring the MLs of Enabling Technology/ICT capabilities based on 20 formulated indicators, and 3) assessing the MLs of Economic SSC based on 30 formulated KPIs.
Methods: The Design Science Research methodology (DSRM) orchestrated the development of BSSC-ML at which design, implementation, data collection & analysis, validation, and evaluation were performed by utilizing semi-structured interviews were conducted with 7 officials of the Information & eGovernment Authority (iGA), while the web content analysis and Delphi methods respectively were employed to analyze the official portals while preserving the validation quality and to evaluate the model.
Results: The findings revealed 50.3% ML score w.r.t 116 Business services and 3 sets of 260 Technology/ICT capabilities, 3rd ML score w.r.t Economic SSC, and 88.123% w.r.t evaluation's acceptance rate.
Conclusion: The study described the development process of BSSC-ML for SSC' Economic MLs assessment at which the evaluation scores proved its effectiveness as a monitoring too for local and global SCs.

Keywords: Technology/ICT Maturity Model, Smart City, Enterprise Architecture, Design and Evaluation, Economic Sustainability.

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I. INTRODUCTION

The concepts of sustainable cities and smart cities (SC) are the most frequently co-occurring topics under the concept of sustainable smart cities (SSC) [1], [2], [3], [4], [5], but also the most confusing as believed by [6] w.r.t the sustainable smartness of cities and smartness of sustainable cities where the former refers to the cities looking to become sustainable in terms of economic, environmental, or social dimensions, while the latter refers to the sustainable cities looking for maintaining and improving their status of sustainability.

SCs integrate through smart planning economy, population, mobility, environment, and administration and wish to be sustainable, innovative, and efficient places [3] and are classified into smart urbanism, smart economy, sustainable and smart environment, smart technology, smart energy, smart mobility, and smart health [7] at which their development and management determine their sustainability [5]. The SCs are classified into 6 dimensions & 18 concepts as in [8], [9]. 3 dimensions & 10 dimensions as in [8], [9], or according to economic, social, and political aspects which are highly related to the QoL through technological development as in [10]. On the other hand, SSC expresses the allowance of SC connection which has emerged in 7 developments including SC, urban ICTs, sustainable cities, sustainable urban development, sustainability and environmental issues, urban growth, and urbanization [11], all being intensively dependent on the usage/utilization of Technology/ICT capabilities.

* Corresponding author

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The Technology/ICT capabilities ensures the fulfillment of the AS-IS and To-be needs and holds the balance between either/all of the economy, environment, and society dimensions of SC [2]towards positive economic growth and the Economic sustainability dimension of SCs [12], [13], [14], [15].

In the context of SSC, the Maturity models (MM) are assessment tools for the continuous analysis and measurement of the AS IS (SC) until reaching the To BE (SSC) [16] and can be utilized for effective and continuous monitoring of Economic sustainability progress [17] based on the characteristics of the domains with indicators which are focused on software development and software engineering [18], models [19], approaches [20], and maturity levels (MLs) which define various levels of maturity at which the subject matter's development/utilization level is placed in a particular level of assessment such as state, importance, requirements, complexity, future need, etc., and for different purposes including descriptive, prescriptive, and/or comparative individually or collectively [19].

Several MM research gaps arise from the state-of-the-art of the SSCs such as [4], [13], [17], [18], [20], [21], [22], [23], [24], [25], [26], to include that most of the recent MMs are: 1) undedicated and overlapping the SC domains, 2) missing details of SC cases, 3) applying indicators from ambiguous databases, 4) unable to identify SC baseline, 5) lacking easiness, usefulness, decision support, comprehensiveness, timeliness, and usage intention, and/or 6) not targeting the Economic dimension of SSC.

The objective of this study is to develop and evaluate an Enterprise Architectural (EA) MM tool (BSSC-ML) as insighted by [2], [26], [27], [28], [29], [30], [31], acting as a continuous monitoring tool to the transition of enterprises (i.e. Bahraini SC) from AS-IS (SC) to TO-BE (SSC's Economic MLs). In other words, the BSSC-ML tool assess the long-term planning progress of the Economic maturity level (ML) which is dependent on the Technology/ICT capabilities Maturity Models (MM) by analyzing and measuring the maturity level (ML) of the SC. To be accepted, the model has to have certain characteristics such as being easy, useful, decision-making supporter, comprehensive, time saving, and intentional of use features. The BSSC-ML is composed of 3 phased EA based MM that can 1) identify, collect, classify, and analyze the enabling Technology/ICT capabilities (Analysis phase), 2) mathematically measure the MLs of three sets of enabling Technology/ICT capabilities based on 20 indicators (Measurement phase), and 3) assess the SSC's Economic MLs based on 30 KPIs (Assessment phase). Moreover, the DSRM is a problem-solving paradigm which creates innovative artifacts (BSSC-ML), which solves problems [32], [33], [34], while the Delphi technique is a technique of evaluation for artifacts [35] that collects reliable responses of experts in the study nature [36], through multiple rounds, multiple questionnaires, and based on multiple criterions [37].

This study proposes two strands of both theoretical and practical sides. The first is proposed through review research of the body of knowledge [16], [38], [39] and is related to three strands of literature such as the IT MM for SSCs w.r.t the employed models, MLs, Technology, and Economic sustainability, from the period of 1999- 2023, while the second is proposed through developing an IT maturity model (BSSC-ML) for the assessment of the Economic SSC MLs, building on the analysis of the enabling Technology/ICT capabilities, measuring the MLs of Technology/ICT capabilities based on 20 formulated indicators, and assessing the SSC's Economic MLs based on 30 formulated KPIs.

II. Literature Review

Technology/ICT has contributed intensively into SC sustainability. For example, [4], [12], [13], [40] discussed the critical roles of ICT for sustainability (ICT4S) from different aspects such as cybernetics, environmental informatics, computational sustainability, sustainable HCI, green IT/ICT, ICT for sustainability, or relatively related to ICT and sustainability such as, ICT for development (ICT4D), ICT for energy (ICT4EE), energy informatics, sustainable computing, digital sustainability. [12], [13] have gone far to consider the Economic sustainability dimension of SCs and admitted the role played by technology/ICT towards economic growth has been positively confirmed, while [22] studied and tested the nexus between technology/ICT and economic development in the organization of economic cooperation and development (OED) countries providing a six levels' model of ICT maturity whereas findings revealed increase of 1% –3.8%. Moreover, [14] demonstrated how technological solutions drive open innovation and is important for enterprises to improve their products and services, to become economically sustainable, while [15] reviewed 215 publications on ICT based Sustainability and found that there is a need for further research in this regard, while [10] estimated the positive and negative effects of the "informatization", by developing a socio-economic model. For the case of Bahrain, the government has launched their Economic Vision 2030 and 2050 which include a set of essential economic principles [17], [21], [41] such as sustainability by prioritizing the economic development factors to align with the SDG which are dependent on the enabling technological applications, systems, and technology capabilities.

The Maturity models (MMs) are characterized by four components including MM domains, MM approaches, MM model development with indicators, and MM assessment with maturity levels (MLs).

For the MM domains, [18] identified 20 domains which were all focused on software development and software engineering, while for the MM approaches, [20] listed five approaches including, 1) techno centered approach, 2) emphasizing hardware, 3) new technologies and infrastructure, 4) human-centered approach (social and human capital), and 5) integrated approach based on qualities and identified dimensions into technology (hardware and software infrastructures such as physical infrastructure, smart technologies, mobile technologies, virtual technologies and digital networks), people, and institutions, while [18] considers maturity models (MM) as applicable assessment tools which are utilized for various purposes for their description of any subject over time including person, technology, company, etc.

For the MM development, [4] developed a case study based IT based MM for smart city from economic and environmental dimensions by studying the Colombian smart city's IT dimensions such as governance, IT services and infrastructure, and data management, while [42] surveyed 17 documents and 16 components to measure MLs in the Indonesian SSC. In addition, [19] introduced several models, two of which are considered popular and comprehensive such as the European Smart Cities Ranking and the ISO indicators for city services and quality of life where the prior consists of six city domains including mobility, environment, living, people, economy, and governance and each and group of factors which are further decomposed into indicators for domain's success while the second is composed of 17 domains including 100 performance indicators, while [43] reviewed several articles to assess IT governance at BSI using COBIT framework by the alignment of BS and IT strategy, delivery of IT value, performing risk management, measuring performance and management of IT resources, while [44] proposed a hybrid network architectural model for the SS through the integration of Software Defined Networking and blockchain technologies. The model was composed of core network & edge network that maintain centralized and distributed networks, security, and privacy. In addition, [21] developed a UK based MMSC which was structured on a modified version of hybrid TOPSIS method to generate smart index it was explicitly dedicated to UK, based on 5 ML, 19 smart dimensions and 111 smart indicators conceptualized by ISO 37120:2018, where the Economic dimension was not considered exclusively.

For the MM assessment, [45] introduced the SO-SCMM to assess smartness for urbanization and infrastructure for 10 city domains in Indian SCs with 4 MLs and indicators distilled from the ISO standard 32710 and Indian government and was limited to Indian cities explicitly and fixed available sources of data, while the GSCM was developed by [42] for the Indonesian SC indicators which focus on 6 areas, 111 indicators, and 5 MLs, while [17] developed the IDC-SCMM to explain the MLs for 5 domains with indicators from British standards PAS 181 but wasn't explicitly able as promised to identify the AS IS state of the SC [21], while developed by [46], the Br-SCMM measured Brazilian SCs in 10 domains and 10 indicators for social and economic policies, however the model was dedicated to Brazil only and three out of five MLs failed to answer how to measure MLs while the indicators were extracted from available public databases. For the MLs, [19] developed and assessed an environmental based indicator system to assess the maturity levels of sustainability of 35 SSCs in China utilizing the International Telecommunication Union (ITU) MM. Also, through an evaluation of a case study, [47] developed an environmental maturity-based sustainability assessment framework based on territorial context analysis to include integrative aspects of sustainability of an Italian case, including system, purpose, strategy, actions and tools at which the descriptive purpose of MM performs the AS-IS assessment of the current capabilities of the subject matter is assessed w.r.t. a certain criterion.

III. METHODS

The research design model as depicted in Fig. 1 is based on the insights of [34] for the Design Science Research (DSRM). The DSRM is defined by [34] as a six phased methodology for the development of IT artifacts (BSSC-ML) and solving of certain organizational problems (Assessment Economic SSC by measurement of enabling Technology/ICT capabilities). Advocated by [35], the DSRM facilities the collaboration of technology, enterprises, and individuals, with real-world scenarios and is found the best for the study at hand as insighted by [28], [29], [31], [32], [34], due to the mix of qualitative and quantitative natures of the study at hand w.r.t the nature of the development process of the BSSC-ML.

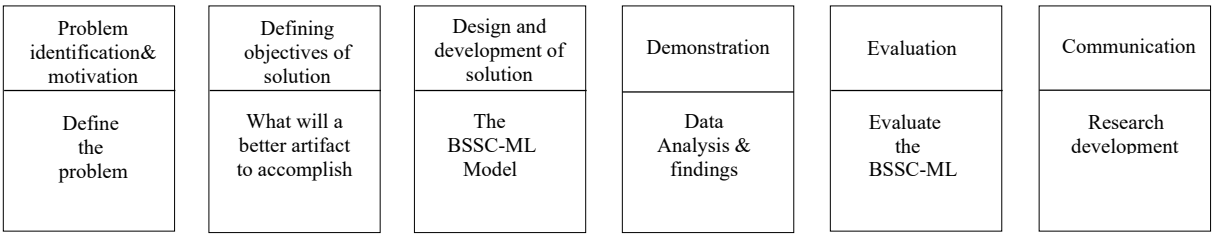

Fig. 1 The research design process.

A. Problem identification and motivation phase

The 1st phase of DSRM is addressed by identifying the research problem w.r.t the previous research limitations and justifying the solution's essence [34]. Despite that Bahrain SC holds several enabling Technology/ICT capabilities, it lacks an overarching, easy, useful, and timely effic ient Technology/ICT MM that is capable to plan and continuously monitor the MLs of Economic SSC, in comparison to other MMs.

B. Definition of the objectives of a solution phase

In the 2nd phase of DSRM, research objectives are derived from the research problem [34]. The study is aimed at monitoring the long-term planning progress of the SSC's Economic maturity level (ML). Derived from that, this study developed and evaluated an Enterprise Architectural (EA) MM tool (BSSC-ML) that is capable to continuously assess the SC's transition from AS-IS (SC) to TO-BE (SSC's Economic MLs) by analyzing the Enabling Technology/ICT capabilities, 2) measuring the MLs of Enabling Technology/ICT capabilities based on 20 formulated indicators, and 3) assessing the MLs of Economic SSC based on 30 formulated KPIs.

C. Design and development of a solution phase

In the 3rd phase of DSRM, constructs, models, or methods are created based on theory [28]. The BSSC-ML is designed, implemented, and validated [36], [37], [40], [42], throughout the employment of several semi-structured interviews (Face to face and/or phone calls) with 7 officials of the Information & eGovernment Authority (iGA) at which an interview protocol document along with 7 templates was prepared and the web content analysis (CA) was performed to analyze the public and private ministries' portals, validation and evaluation of BSSC-ML were conducted.

Depicted in Fig. 2, the BSSC-ML model is composed of three modules as insighted by [28], [29], [31], [32], [34]. The 1st module identifies, collects, classifies, and analyzes the business and enabling Technology/ICT capabilities (Analysis), while the 2nd Module measures the MLs of the enabling Technology/ICT capabilities (Measurement), and the 3rd Module assesses the ML of the Bahraini Economic SSC (Assessment) of the Technology/ICT enabler's MLs of the SSC to generate services that can improve the economic sustainability. The BSSC-ML develops comprehensive and precise indicators and mappings against [2], [28], [29], [30] by developing 1) analysis of 260 enabling Technology/ICT capabilities, 2) measurement of MLs of those capabilities of 3 subdomains based on 20 formulated indicators, and 3) assessment of the Economic SSC based on KPIs. Technology/ICT capabilities (applications, systems, and technologies) will be analyzed according to the business, application, and technology architectures of Bahrain SC leading to a measurement of the ML of the enabling Technology/ICT capabilities which help to assesses the ML of the Economic SSC.

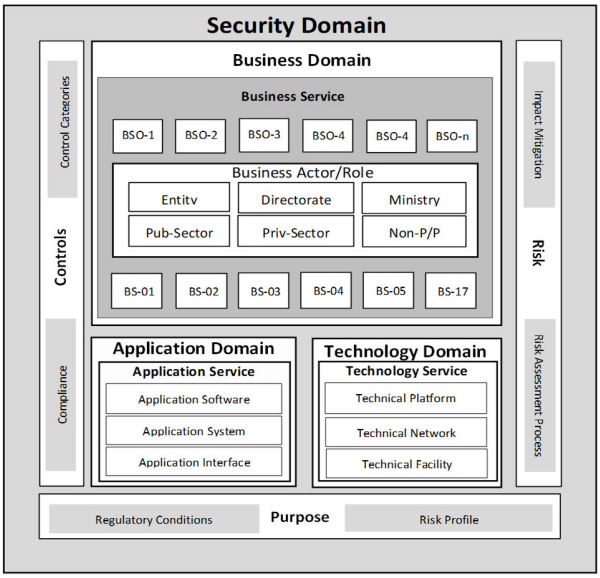

Fig. 2 The analysis module of the BSSC-ML model

1) The 1st module (Analysis)

The analysis phase acts as a tool for the identification and collection via 7 templates for data collection, categorization into three sets (Service, infrastructure, Governance), and analysis of the AS-IS enabling Technology/ICT capabilities (applications, systems, and technologies) of the subject matter (Bahraini SC) according to the EA based secured domains (Business, Application, Infrastructure) and analyzed according to the Business Service (BS), Application Services (AppS), and Infrastructure services (TS), for the subsequent 2nd Module as depicted in Table 1. In addition, the Security domain is a uniform, integral, and aligning architectural Business, Application, and Infrastructure domains in terms of risk reduction and regulatory compliance and is categorized into three areas; purpose, risk, and controls. Alternatively, Business domain is composed of Business Strategic Objectives (BSO), Business Service (BS), and Business Actors/Roles (BA/R). Therefore, The Bahraini SSC's Business domain as demonstrated in is composed of 17 Business Services (BS1.00-1.16). However, the Business Actors/Roles (BA/R) include 17 governmental ministries (BA/R 1.00-1.13), 14 governmental directorates (A/R 2.00-2.13), and 35 governmental entities (BA/R 3.00-3.34), and 18 non-public/private Business Actors (BA/R 4.00-4.17). The Application domain is derived by the Business domain and is composed of 26 Application Service sets (ApS1.00 – 1.25) , 12 Application Systems (ApSys 2.00 - 2.11), 13 Application SW (ApSW 1.00- 1.12), and 1 App Interface protocol (ApIP 3.00). The Infrastructure domain, however, is derived by the Business and Application domains and is composed of 3 Infrastructure services (TS 4.00-4.02, 4.03-4.05,4.06) and 18 subservices (TS 4.0.1- 4.6.2).

2) The 2nd module (Measurement)

This phase measures the MLs of the Enabling Technology/ICT capabilities which were previously identified, collected, categorized, analyzed in module 1. There are 5 levels of maturity which are measured against 20 indicators. Each of the three enabling Technology/ICT domains is awarded a maximum score of 100% capacity with a calculation scale of 1-5 (according to the SS level). Each value increments in multiples of 20. At ML1 (Ad-hoc), there exists no SSC strategy and associated plan, while at ML2 (Initial level), the SSC initiatives should be aligned with the Bahraini SSC strategy. At the ML3 (Scattered level), the Bahraini SSC should deploy the SSC initiatives, SSC services based on technology/ICT infrastructures service centers, mobile apps and web portals, while at ML4 (Integrated level), the Bahraini SSC needs to have integrated systems and data to deliver city services at which several technologies (Internet of things (IoT), cloud computing, artificial intelligence and other advanced technologies) are applied to satisfy interoperability. At the ML5 (Smart level), the SSC needs to have a continuous improvement of SSC. Illustrated in Table 2, a set of 20 indicators was formulated to represent the progress (digitalization) of the Enabling Technology/ICT Capabilities' domain and are categorize d into 3 subdomains including ICT service (5 indicators), ICT infrastructure (11 indicators), and ICT Governance (4 indicators). The ML is measured according to (1), where the overall ML (%) is measured, added, and then divided by the 3 subdomains as in (2).

TABLE 2
MEASUREMENT OF THE ML OF THE ENABLING TECHNOLOGY/ICT CAPABILITIES

Domain	Sub Domain	Indicators	The Enabling Technology/ICT ML						
			ML-1 Ad-hoc 0-20%	ML-2 Initiative >20-40%	ML-3 Scattered >40-60%	ML-4 Integrated >60-80%	ML-5 Smart >80-100%	(%)	ML
Enabling Technology/ICT Capabilities	ICT Service	Technology/ICT services/used application	-	-	-	√	-		
		Online Community Services	-	-	-	√	-		
		Service based Applications	-	-	-	√	-	-	-
		Integrated Applications	-	-	-	-	-		
		Applications to be developed	-	-	-	-	-		
	ICT Infrastructure	Connection to a network	-	-	-	-	√		
		Internet bandwidth availability	-	-	-	-	√		
		Household internet access	-	-	-	-	√		
		Fixed broadband subscriptions	-	-	-	√	-		
		Fixed broadband coverage	-	-	-	√	-		
		Wireless broadband subscriptions	-		√	-	-	-	-
		Availability of high-speed fixed broadband	-	-	√	-	-		
		Availability of high-speed mobile broadband	-	-	√	-	-		
		Availability of Wi-Fi in public areas	-	-	√	-	-		
		Internet use in OPD	-	-	-	-	-		
		Existence of data centers	√	-	-	√	-		
	ICT Governance	Policies/ regulations of Technology/ICT		-	√	-	-		
		SOP related to the use of Technology/ICT		-	√	-	-		
		Human resources relevant Technology/ICT	√	-	-	-	-	-	-
		Technology/ICT planning documents	√	-	-	-	-		
Average Economic SSC ML (%)								-	-

$$Maturity = (\sum_{Dimension\ a}^{Dimension\ n}(Total\ indicator\ val/_{Total\ max\ val}) * Weight)\ no.of\ domain \quad (1)$$

$$Maturity\ level = \sum_{Technology\ value\ a}^{Technolog\ value\ n} Technology\ value\ /3 * 100\% \quad (2)$$

3) The 3rd module (Assessment)

In this phase, the Economic SSC is assessed by summing the MLs of the enabling Technology/ICT domains w.r.t the 30 KPIs against the three subdomains as illustrated in Table 3. The assessment of the Economic SSC is measured by dividing the ML (%) of the enabling Technology/ICT subdomains by 3.

$$Economic\ BSSC\ ML = \sum_{Maturity\ level\ a}^{Maturity\ level\ n} Maturity\ Level\ /3\ * 100\% \quad (3)$$

D. Demonstration phase

The 4th phase of DSRM represents the use of the artifact to solve the problem [27]. The implementation and analysis of the findings of BSSC-ML are addressed to eventually answer the research aim, objectives, and problem of the study [24], [25], [47], [48].

1) Data collection and analysis

Several data collection methods were embraced for eliciting the AS- IS of the Enabling Technology/ICT Capabilities of the SSC, including, A) Semi-structured interviews with 7 officials of the Information & eGovernment Authority (iGA) to get acknowledged of the Bahraini Technology/ICT SC initiatives, B) Previous quantitative data sets as in [28], [29]. Interviews were conducted and initiated by making telephone calls and sending email invitations, followed by updating BSSC-ML architecture, getting answers via phone calls/emails as per the interview protocol document, and C) 9 phased web content analysis (CA) method which were all performed for analyzing the official Bahraini public ministries and private web portals of the SSC w.r.t the transcription and analysis of the data collected [28], [29], [31], [32].

The Semi-structured interviews with an interview guide of questions is added to an explorative questions by the interviewee of which the qualitative telephonic calls is an example [49]. Telephonic qualitative research interviews are more favorable due to the methodological validation, saving of time, reducing cost of meeting with larger number of interviewees, not restricting locations, less demanding, greater flexibility, greater anonymity and lesser intensity, and privacy [49], [50], [51]. The web content analysis/textual analysis (CA) is suitable for qualitative and/or quantitative types and refers to the usage of scientific methods to qualitative or quantitative documentary evidence, where the prior is interpretive in nature and does not utilize statistical analysis. Aside from its minimal challenges of its mixture of many media features and time of data collection, the outcome of applying CA to web-based content is admitted by several studies to be less biased and collection reporting time ranges from 2-60 days compared to questionnaires, interviews, and tests [52]. The 9 stages include 1) formulating research questions where research questions are identified, 2) Identifying variables where variables are conceptually formulated, 3) Defining categories and units of measurement where categories and units of measurement are defined, 4) Creating coding scheme, 5) Sampling is determined, 6) Pilot reliability where code book is revised, 7) Coding, 8) Calculating final reliability, and 9) Data analysis [52].

2) Validation

Construct and external validity and reliability tests were performed to validate the quality of the interviews [53]. During the research design and data collection stages, external validity was satisfied from the fact that this study was drawn from the substantial lack of previous EA based studies and the enterprises in the Bahraini SC were selected based on the data requests and/or have web portals. Construct validity for data collection and composition stages was claimed by establishing precise operational measures for the study concepts throughout mapping the data collection questions and measures to the research objectives and to produce a chain of evidence (Triangulation) at which the collected Technology/ICT data was regularly reviewed during the composition stage of collection and stored in a repository to guarantee concise collection of procedures and findings.

TABLE 3
THE ECONOMIC DIMENSIONS, KPI INDICATORS AND ML GOALS & ACHIEVEMENTS OF THE BSSC-ML

Dimension	S-dim	KPI	KPIs	ML1 (Current)			ML2 (30%)			ML3 (40%)			ML4 (60%)			ML5 (80%)		
				KPI-L1	Goal	Achievement	KPI-L2	Goal	Achievement	KPI-L3	Goal	Achievement	KPI-L4	Goal	Achievement	KPI-L5	Goal	Achievement
Economic	ICT	KPI-01	Household internet access	X	To have a SSC strategy, roadmap or strategic plan, and an overall city governance	–The city has developed a detailed strategy to reach out to the relevant stakeholders, including the evaluation of budget, resources and costs related to SSC development. –There is a designated senior manager or management team with the responsibility to implement the SSC strategy, coordinate and oversee all smart city initiatives, facilitate co-ordination and identify synergies between them. –Common terminologies relating to SSC and common reference model are agreed. –Priorities for SSC developments are identified in terms of technologies and initiatives. –Assessment plan and KPI targets for each maturity level are ready. –Current KPI values are collected.		To align SSC initiatives with the SSC strategy by deploying ICT infrastructures to support operations for SSC development.	–Development plan for infrastructure that is ready according to the overall SSC roadmap of the city. –ICT infrastruc identified to support SSC initiatives. –ICT Infrastruc are able to independently operate to provide various SSC services. –Records of ICT infrastruc are built and periodically updated. –Self-assessment on ICT infrastructure and services that is conducted periodically. –Performance improvements are achieved regarding the target KPI values for maturity level 2 as planned in the city SSC strategy.		To deploy specific SSC based ICT infrastructures services via local community service centers, mobile apps & web portals.	–Departments of the city council or specific authorized organizations, and private-sector companies build separate platforms or systems to systematically manage resources and data. –Accessibility of services that are offered via various channels, such as mobile applications, web portals, service platforms, local community terminals. –Services are upgraded via functional improvement. –Application operation is monitored and analyzed to improve service performance and quality. –User satisfaction assessments are conducted for targeted communities periodically. –ML-KPI target value improvt are achieved.		To ensure that systems, data, IoT, CC, AI, and other advanced tech are integrated to deliver quality & interoperable sservices.	–ICT infrastructure interoperability is achieved – Coop across infrastruc, systems and/communities is established. –Cross-domain platform and applications are provided. – Open data is available to the public from different sources as appropriate. – Satisfaction assessments of stakeholders and service providers are conducted periodically. – Performance improvements are achieved regarding the target KPI values for maturity level 4 as planned in the city SSC strategy.		To continually improve SSC by finding services to reduce citizens, operational costs by collaboration bet sys services & apps.	–Services, applications and cooperation based on collaborative systems are continuously improving. – Manage and operation based on qualitative and quantitative analyses are established. – Continual improvement of services and applications made possible by applying the use of technologies. –Systematic assessment process is established to carry out continuous improvement and performance evaluations. –Results of assessment & evaluation are analyzed, and action plans are implemented.
		KPI-02	Fixed broadband subscriptions	X														
		KPI-03	Wireless broadband subscriptions	X														
		KPI-04	Wireless broadband coverage	X														
		KPI-05	Availability of Wi-Fi in public areas	X														
		KPI-06	Availability of Wi-Fi in public areas				X											
		KPI-07	International Internet bandwidth				X											
		KPI-08	Use of Internet by city inhabitants				X											
		KPI-09	Coverage rate of digital broadcasting network				X											
		KPI-10	Availability of ultra-h-speed wireline				X											
		KPI-11	Availability of high-speed mobile broadband				X											
		KPI-12	Availability of smart phones and tablets				X											
		KPI-13	Quality of fixed broadband				X											
		KPI-14	Quality of mobile broadband				X											
		KPI-15	Household with a mobile device				X											
		KPI-16	Smart water meters	X														
		KPI-17	Water supply ICT monitoring	X														
		KPI-18	Water saving in households							X								
		KPI-19	Drainage/storm water system ICT monitoring	X														
		KPI-20	Smart electricity meters	X														
		KPI-21	Electricity supply ICT monitoring	X														
		KPI-22	Demand response penetration	X														
		KPI-23	Dynamic public transport information	X														
		KPI-24	Traffic monitoring	X														
		KPI-25	Intersection control	X														
		KPI-26	Open data	X														
		KPI-27	e-Government	X														
		KPI-28	Public sector e-procurement	X														
		KPI-29	e-Public services adoption							X								
		KPI-30	Open data										X					

E. Evaluation phase

The 5th phase of the DSRM assesses the acceptance rate of the artifact [32] by utilizing Delphi evaluation technique which identifies the acceptance based on the results of multiple rounds of questionnaires sent to a panel of experts as insighted by [35], [36], [37], [54], [55]. The number of rounds, panel size, panel duration, selection of experts, selection criterion, and variables of acceptance were formed in a way that 2 online questionnaires were designed and distributed to 7 experts in 2 rounds of 2-3 weeks gap to evaluate the perceived acceptance level of BSSC-ML based on the 6 variables of the technology acceptance model (TAM model) which has been used in several studies to evaluate IS/IT solutions [56]. The 7 experts were selected according to 3 qualifications including the interest in the SSC, IT/ management work experience for 5 years, and involvement in the technological decision-making. The 6 variables include ease of use, usefulness, decision making support, comprehensiveness, required time, and intention to use. Ease-of-Use measures the degree to which an expert believes that using the model is free of effort, while Usefulness measures the degree to which an expert agrees that using the model enhances the objective. Decision making-support measures how much the model provides support for the objective, while Comprehensiveness measures how overarching the model is. Required time measures the time required to complete the model, while Intention to use measures how likely the decision-maker will use the model.

F. Communication phase

The 6th phase of DSRM demonstrates the importance and effectiveness to the researchers at which the identified problem and the suggested solution are documented as a research publication [26], [27].

IV. RESULTS

A. Analytical findings

For the Bahraini SC, the government and in order to satisfy the economic vision 2030 and 2050, it obliges that the ICT eco-system and telecom becomes smarter to benefit consumers, business, government, and environment (BA/R). Since 1998, Bahrain achieved four national telecom plans to serve the Business actors including public and private sectors and during 2016-2018 launched the 4th plan of the development of a single national broadband network (NBN) ensuring that the Technology/ICT providers grant consumers an access to 95% of all households and 100% of all companies to a ubiquitous ultra-high speed fixed and mobile broadband networks of IP-based interactive, multimedia, IOT, M2M communications, and enhances the Technology/ICT capabilities and sustains CC services to mitigate costs, enhance security and productivity. Recall the Business, application, and infrastructure layers of the SSC.

Table 4 demonstrates the BSs, AppSs, and TSs as insighted by [26], [27], [29], [30] to identify, categorize, and analyze 116 BS, 130 AppS and 130 TSs, including BS 1.00 Defence, BS 1.01 Internal& external affairs, BS 1.02 Education and Training , BS 1.03 Energy , BS 1.04 Finance , BS 1.05 Foreign Affairs ,BS 1.06 Health & Welfare , BS 1.07 Housing , BS 1.08 Industry, BS Commerce & Tourism, BS 1.09 Media & Comm , BS 1.10 Law enforcement& Public safety, BS 1.11 Justice & Islamic affairs ,BS 1.12 Workforce , BS 1.13 Parl. affairs ,BS 1.14 Transportation & Telecomm, BS 1.15 Works, Municipalities & Urban planning Affairs, and BS 1.16 Youth & Sports. AppS 1.00 Analytical report, AppS 1.01 Data (BSC, Bus Intelligence, DSS, On Demand, Forensics Mathematical, Anal Processing, Portfolio Stat), AppS 1.02 Development, AppS 1.03 Document Mgt, AppS 1.04 Geospatial, AppS 05 Knowledge Mgt (Data Mining, Information Retrieval, Knowledge Capture, Knowledge delivery, Modelling), AppS 1.06 MW (Msg SW, Service UI), AppS 1.07 Process mgt, AppS 1.08 Production, AppS 1.09 Security Digital Signature, Encryption, Virus Protection), AppS 1.10 Communication (Email, Event Mgt, Ins Msgs., Social SW, Mgt), AppS 1.11 Visualization, AppS 1.12 Web access (S. Engine, Browser), AppS 1.0.1 Reporting, AppS 1.1.1 Recovery, AppS 1.2.1 Development, AppS 1.3.1 Imaging, AppS 1.4.1 Cartography, AppS 1.5.1 Categorising, AppS 1.6.1 Service Bus, AppS 1.7.1 Proc Mgt, AppS 1.8.1 Drawing, AppS 1.9.1 Authentication, AppS 1.10.1 Calendar, AppS 1.11.1 Charting, and AppS 1.12.1 Portal. AppS 2.00 Acq Mgt (Invoice Tracking, Procurement, Vendor Mgt), AppS 2.01 Customer Service, AppS 2.0.2 Emergency Mgt (Mgt ,Emergency), AppS 2.0.3 Financial Mgt (Acc Payable, Acc Receivable, Budget, Auditing, Ledger), AppS 2.0.4 Grant Mgt, AppS 2.0.5 Work Mgt (Reso- Plan, Skills Mgt, Org Mgt), AppS 2.0.6 HR Mgt, AppS 2.0.7 Legal Mgt, AppS 2.0.8 Safe Mgt, AppS 2.0.9 Production Mgt (Facilities, Inventory, Logistics, Media, W.H Mgt), AppS 2.0.10 Security Mgt (Ident Mgt, Inciden Mgt, Intrusion), AppS 2.0.11 System Mgt, AppS 3.0 Application prototype. Moreover, TS 4.0.1 Platform (I-HW), TS 4.0.2 Network (I-OS), TS 4.0.3 Facility (I-Comm. HW). TS 4.0.1.0 includes Server, Personal Computer, Mobile Device, while TS 4.0.1.2 includes Network Interface Device, Telephony Handset, Radio Unit. TS 4.0.2.0 includes Public, Private while TS 4.0.2.1 includes Data, Voice, Video, while TS 4.0.2.2 includes Wired & Wireless Network. TS 4.0.3.0 includes Bahrain, International. The maturity levels (MLs) revealed 45%, 70.9%, and 35% w.r.t. the ICT Service, ICT Infrastructure, and ICT Governance subdomains respectively with an overall average (%) of 50.3%, while the Bahraini

Economic SSC scored the 3rd ML, 4th ML, and 2nd ML w.r.t. the 3 subdomains respectively with an overall average of 3rd ML as appearing in Table 5.

TABLE 5
THE ASSESSMENT OF THE ECONOMIC ML OF SSC

Do	Sub Domain	Indicators	The Economic SSC based Enabling Technology/ICT ML					
			ML-1	ML-2	ML-3	ML-4	ML-5	Economic SSC
Enabling Technology/ICT Capabilities	ICT Service	Technology/ICT services/used application	-	-	-	78%	-	45%
		Online Community Services	-	-	-	78%	-	
		Service based Applications	-	-	-	69%	-	
		Integrated Applications	0%	-	-	-	-	
		Applications to be developed	0%	-	-	-	-	
	ICT Infrastructure	Connection to a network	-	-	-	-	100%	70.9%
		Internet bandwidth availability	-	-	-	-	100%	
		Household internet access	-	-	-	-	100%	
		Fixed broadband subscriptions	-	-	-	80%	-	
		Fixed broadband coverage	-	-	-	80%	-	
		Wireless broadband subscriptions	-		50%	-	-	
		Availability of high-speed fixed broadband	-	-	50%	-	-	
		Availability of high-speed mobile broadband	-	-	50%	-	-	
		Availability of Wi-Fi in public areas	-	-	50%	-	-	
		Internet use in OPD	-	-	-	-	-	
		Existence of data centers	20%	-	-	60%	-	
	ICT Governance	Policies/ regulations of Technology/ICT		-	50%	-	-	35%
		SOP related to the use of Technology/ICT		-	50%	-	-	
		Human resources relevant Technology/ICT	20%	-	-	-	-	
		Technology/ICT planning documents	20%	-	-	-	-	
Average Economic SSC ML (%)								50.3%

TABLE 6
THE EVALUATION FINDINGS OF THE BSSC-ML.

Criteria	Items	Round 1		Round 2	
		Mean	SD	Mean	SD
Ease of Use	It is easy to perform the modules required by the model.	4.286	0.571	4.571	0.286
	It is clear and understandable to interact with a model.	3.857	0.476	4.000	0.333
	It is flexible to interact with the modules of the model.	4.286	0.571	4.714	0.238
	Overall, BSSC-ML model is easy to use.	4.000	0.333	4.000	0.333
Usefulness	Using the model saves my time.	4.286	0.571	4.286	0.571
	Using the model improves my performance.	4.000	0.333	4.000	0.333
	Using the model improves my productivity.	4.286	0.571	4.429	0.286
	Using the model enhances my effectiveness.	4.000	0.667	4.143	0.476
	I find the BSSC-ML useful.	3.857	0.476	4.000	0.333
Decision-support	Using the model provides the necessary and sufficient support to the objective.	4.143	0.476	4.286	0.238
	There would be adequate support for the decision to implement the objective.	4.000	0.333	4.000	0.333
	The model is important support to the decision to implement the objective.	4.143	0.143	4.143	0.143
Comprehensiveness	The model is including all the required phases to achieve the objective.	5.000	0.000	5.000	0.000
	The model provides comprehensive phases to guide implementation of objective.	4.714	0.238	4.857	0.143
	Overall, BSSC-ML model is comprehensive	4.857	0.143	5.000	0.000
Required time	The model requires time to perform and complete.	4.000	0.667	4.286	0.333
	The model is able to provide the needed at the required time.	3.857	0.500	4.143	0.167
	The model is efficient w.r.t time required to complete.	4.000	0.000	5.000	0.000
Intention to use	I intend to use the model in the future.	4.857	0.143	5.000	0.000
	I am willing to encourage other decision-makers to use the model.	4.571	0.286	4.857	0.143
	I would use the model in the near the future.	4.857	0.143	5.000	0.000
	Total Average (%)	88.13%			

A. Evaluation findings

Apparently in Table 6, the descriptive statistics of the evaluation of the BSSC-ML revealed an overall average of 88.13% that is, four items were used to measure the ease-of-use criterion at which the descriptive statistics in both rounds score 84.28%, while five items were used to measure the Usefulness at which the descriptive statistics in both rounds score 82.58%. Three items were used to measure the Decision-support at which the descriptive statistics in both rounds score 82.38%, while three items were used to measure the Comprehensiveness at which the descriptive statistics in both rounds score 98.09%. Three items were used to measure the Required time criterion at which the descriptive statistics in both rounds score 84.28%, while three items were used to measure the Intention to use at which the descriptive statistics in both rounds score 97.13%.

TABLE 4
THE DETAILED BUSINESS SERVICES, APPLICATION SERVICES, AND TECHNOLOGY SERVICES

BS	B-Public	B-Private	AppS	AppN_id	AppN	TS	I- HW-id	I-OS-id	I-Comm. HW	I-Zone-id	I-Type-id	I-Infrastruct	I-Location	BS	B-Public	B-Private	AppS	AppN_id	AppN	TS	I- HW-id	I-OS-id	I-Comm. HW	I-Zone-id	I-Type-id	I-Infrastruct	I-Location
1.01	1.01	N.A	N.A	N.A	N.A	4.0.3	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.08	1.08	N.A	2.08	2.08	Safety mgt	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.01	1.10	N.A	N.A	N.A	N.A	4.5.2	4.0.1	4.1.1	4.2.1	4.3.1	4.4.1	4.5.1	4.6.1	1.08	1.08	N.A	2.09	2.09	Property Mgt	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.01	1.01	N.A	1.05	1.5.2	Storage app	4.00	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.09	1.1	N.A	1.03	1.3.6	E-Media Visa	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.01	1.10	N.A	1.03	1.3.6	E-Visa application	4.0.0	4.0.1	4.1.1	4.2.1	4.3.1	4.4.1	4.5.1	4.6.1	1.09	1.09	N.A	1.03	1.3.1	NW &content deli.	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.01	1.01	N.A	2.07	2.7.3	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.09	1.09	N.A	1.01	1.1.1	Media services	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.02	1.02	N.A	1.02	1.2.2	Developer tools	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.09	1.09	N.A	1.11	1.11.3	Media services	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.02	1.02	N.A	1.09	1.9.2	Machine learning	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.09	1.09	N.A	1.11	1.11.6	Game develop.	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.02	1.02	N.A	N.A	4.0.3	N.A	4.0.0	4.0.3	4.1.3	4.2.3	4.3.2	4.4.1	4.5.2	4.6.1	1.09	1.09	N.A	2.11	2.11.2	Desktop stream	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	N.A	4.1	1.01	1.1.3	Geographic Info	4.0.0	4.0.3	4.1.3	4.2.3	4.3.2	4.4.1	4.5.2	4.6.1	1.09	1.09	N.A	N.A	N.A	N.A	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	N.A	4.1	1.04	1.4.3	GIS maps app	4.0.0	4.0.3	4.1.3	4.2.3	4.3.2	4.4.1	4.5.2	4.6.1	1.09	1.09	N.A	N.A	N.A	N.A	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	1.03	N.A	1.00	1.0.4	Analytical tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.09	1.09	N.A	1.03	1.03	Doc/Content Mgt	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	1.03	N.A	N.A	N.A	N.A	4.0.1	4.0.3	N.A	N.A	N.A	N.A	N.A	N.A	1.10	1.10	N.A	1.7	1.7.4	Migration	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	1.03	N.A	N.A	N.A	N.A	4.0.3	N.A	N.A	N.A	N.A	N.A	N.A	N.A	1.10	1.10	N.A	1.07	1.7.	Process autom.	4.0.0	4.0.3	4.0.3	4.0.3	4.0.3	4.0.3	4.0.3	4.0.3
1.03	1.03	N.A	1.01	N.A	Data Management	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	1.11	1.11	N.A	1.00	1.0.1	Analytical tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.03	1.03	N.A	1.04	N.A	Geospatial Info	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	1.12	3.2	N.A	2.01	2.1.1	Expat Mgt. (EMS)	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.04	1.04	N.A	2.03	2.3.0	SW & Cost mgt.	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.12	1.12	N.A	2.05	2.5.2	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.04	1.04	N.A	2.06	2.6.3	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.12	3.2	N.A	2.06	2.6.7	Appointment Sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.04	1.04	N.A	2.03	2.3.3	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.12	3.2	N.A	2.01	2.1.1	E-Support Sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.04	1.04	N.A	2.04	2.4.1	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.12	1.12	N.A	2.0.5	N.A	Workforce mgt	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.04	1.04	N.A	N.A	N.A	N.A	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	1.14	2.12	N.A	1.05	1.5.1	Track and Trace	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.05	1.05	N.A	2.01	2.1.1	Cust engagement	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.10	N.A	1.01	1.1.8	Renew P.O. Box	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.05	N.A	N.A	N.A	N.A	N.A	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	1.14	2.12	N.A	1.05	1.5.1	Shipping Rate Calc	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.05	N.A	N.A	N.A	N.A	N.A	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	4.0.1	1.14	1.14	N.A	1.12	1.12.2	BAH Loc. Website	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.3	4.5.2	4.6.1
1.06	1.06	N.A	1.01	1.1.7	Database Mgt app	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.3	Mobile GIS app	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.06	1.06	N.A	2.06	2.6.4	Database Mgt Syst	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Mobile GIS app	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.06	1.06	N.A	2.11	1.0.3	Machine learning	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	1.14	N.A	1.04	1.4.3	Min.Educatin. GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.07	1.07	N.A	2.09	2.9.1	Database Mgt Syst	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Min.Educatin. GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	N.A	1.10	1.10.3	E-tourism app	4.0.0	4.0.1	4.1.1	4.2.1	4.3.1	4.4.1	4.5.1	4.6.1	1.14	1.14	N.A	1.04	1.4.3	Min.Health GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	2.11	N.A	1.12	1.12.1	BMD web portal	4.0.0	4.0.1	4.1.1	4.2.1	4.3.1	4.4.1	4.5.1	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Min.Health GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	N.A	1.08	1.8.4	Bus. productivity	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	1.14	N.A	1.04	1.4.3	Mini.Soc. dev. GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	4.12	1.12	1.12.1	Magento webstore	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Mini.Soc Dev. GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	4.12	1.12	1.12.2	Magento webstore	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Mini.Soc Dev. GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	4.12	1.12	1.12.1	WooCommerce	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.3	Real Estate GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	4.12	1.12	1.12.2	WooCommerce	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.04	1.4.4	Real Estate GIS	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	4.12	1.12	1.12.1	Monster comm.	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.10	1.10.3	Mobile services	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	4.12	1.12	1.12.1	Monster comm.	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.05	1.5.2	Developer tools	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	N.A	1.02	1.2.6	Standards Store	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.01	1.0.4	Management tools	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	N.A	1.12	1.12.1	Commercial Reg.	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	3.34	N.A	1.12	1.12.1	Web portal	4.0.0	4.0.1	4.1.1	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1
1.08	1.08	N.A	1.12	1.12.1	Online Payment	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.09	1.9.1	Sec id &compl.	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.2	1.2.6	E-Trademark Svs.	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	N.A	1.11	1.11.3	Internet of things,	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.01	1.10.3	Promotion Camp.	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	1.14	4.13	2.03	2.3.1	b-Wallet	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.07	1.7.1	Business Activity	4.0.0	4.0.3	4.1.3	4.2.3	4.3.1	4.4.1	4.5.2	4.6.1	1.14	2.11	N.A	2.05	2.5.1	Airport Res. Mgt.	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.01	1.0.3	Analytical tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.01	2.10.2	Access control sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.01	1.1.3	App integration	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.01	2.10.2	Biometrics sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	2.01	2.1.2	Indus Services Sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.11	2.11.1	Aeronautical Sys	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	2.08	2.8.1	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.11	2.11.1	Aeronautical pub	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	2.09	2.9.1	Management tools	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.11	2.11.1	Aeronautical circu	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1
1.08	1.08	N.A	1.12	1.12	Web access	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1	1.14	2.11	N.A	2.11	2.11.1	E- flight Inf bullet	4.0.0	4.0.1	4.1.1	4.2.1	4.3.2	4.4.1	4.5.1	4.6.1

V. DISCUSSION

Developing countries target to continuously monitoring the long-term planning progress of the Economic Sustainability which creates a major challenge in the realization of a SC [2], [12], [13], [14], [15] and is highly reliant on the assessment of maturity levels of the Enabling Technology/ICT capabilities of SCs [16]. A comprehensive LR as in section 2 revealed the existence of several MMs as in [18], [20] but having several weaknesses which dissatisfy the desired rigor of Economic MM's assessment [4], [13], [17], [19], [21], [42], [43], [44], [45], [46] and ML measurement [19], [47]. Also, the LR revealed that previous MMs were found: 1) undedicated and overlapping the SC domains such as FSCE2 in [4] which doesn't dedicate the model for SCs/SSCs, [42] which developed a fuzzy cognitive map (FCM) of the components and their interrelationships and indicators relevant to Indonesia, or [19] which developed a generic development framework and embraced several overlapping domains such as infrastructure, digital transformation, data, labor market, entrepreneurship, etc., or [23] which proposes a holistic approach to the assessment of smart city governance and policy decision making of the citizen centricity and the processes, or [24] which critically analyzed 34 SC assessment tools and evaluated against an analysis framework that covers criteria related to comprehensiveness, stakeholder engagement etc, and [25] which embraced different perceptions of the SC concept, 2) missing details of SC cases such as in [4], [25] which had no detailed SC cases, 3) applying indicators from ambiguous databases such as [23] which used London Datastore open data (600 public data sets) to increase citizen engagement such as [24] which focused on technological indicators sets, were found not appropriately covering SC dimensions, and not suitable for informing smart city planning in addition to [21], [22], [46], 4) unable to identify SC baseline such as [21] which didn't analyze the AS-IS when using the TOPSIS method, 5) lacking easiness, usefulness, decision support, comprehensiveness, timeliness, and usage intention such as [4] that didn't provide evaluation for the FSCE2 development, and/or 6) not targeting the Economic dimension of SSC such as [4], [19] which don't consider the economic dimension of SCs as well as [21], [45] which proved the model efficiency for assessing the smart maturity level of a city.

Throughout a standard six phased DSRM and as insighted by [2], [26], [27], [28], [29], [30], [31], this study introduces the development of a three module Enterprise Architectural based maturity model entitled (BSSC-ML) aiming at providing a continuous planning and monitoring assessment of the Economic level of sustainability of a SC at which the EA model provides analysis of common core elements and relationships of a socio-technical enterprise (SC) and organizes the business processes, data, and information technologies in order to manage complexity [28], [29], [30], [31].

The BSSC-ML is meant to be 1) emphasizing the Technology/ICT dimension of a SC for sustainability w.r.t the SC dimensions of smart cities, considering the analyzed details of the SC w.r.t. to other SCs, 2) following standard definitions of SCs such that a city and Technology/ICT based sustainable development should include economic or social, or political aspects which are highly related to the QoL through technological development at which our focus was on the Economic aspect, 3) employing the 3 EA layers (i.e. BA, AppA, TA) which allows for a reliable AS IS monitoring and continuous analysis and measurement until reaching the desired TO BE maturity, 4) avoiding the existence of several Economic SSM's MMs in previous works which were based on the MLs of Technology/ICT but their characteristics, mechanisms, and adaptations differing from a country to another based on interpretations of definitions under specific conceptualization and SSC dimensions, and 5) scoring high acceptance rate which enthuses utilizing the model as a standard worldwide monitoring tool.

The 1st module identified, collected, classified, and analyzed the enterprises and the Enabling Technology/ICT capabilities revealing 17 Business Services (BS1.00-1.16), 84 Business Actors/Roles (BA/R) of governmental ministries, governmental directorates & entities, and non-public/private Business Actors, 52 Application Service sets, Application Systems, Application Software, and Application Interface protocol, and 21 Infrastructure services and 18 subservices. The 2nd module measured the MLs of the Enabling Technology/ICT capabilities, based on 20 indicators, revealing 50.3% ML findings based on the two measurement equations which reflects a scattered maturity level recommending the SSC to deploy further SSC initiatives, SSC services based on technology/ICT infrastructures (service centres, mobile apps and web portals). The 3rd module was mathematically able to assess the ML-3- ML-4 of the Economic SSC (Assessment) based on 30 KPIs as in Table 3 w.r.t the Technology/ICT enabler's MLs of Table 2, to generate services that can improve the Economic sustainability of the SC. The resulting ML reflect the SSC's need to deploy specific SSC based ICT infrastructures services via local community service canters, mobile apps & web portals. and should have integrated systems and data to deliver city services at which several technologies (Internet of things (IoT), cloud computing, artificial intelligence and other advanced technologies) are applied to satisfy interoperability.

However, there are some limitations which are represented by the recency of the collected data set at which the data of the SSC was collected based on 1) Semi-structured interviews that acknowledge the SCs' Enabling Technology/ICT initiatives, 2) previously published data sets, and 3) CA for the analysis of the official web portals. The Enabling

Technology/ICT initiatives of a SC may have increased and/or unrevealed since the date of data collection which therefore may impact the revealed findings of the MLs of Technology/ICT SC and Economic SSC.

The evaluation findings revealed the ease of use in contrary to other tools as in [21], [25] for example, usefulness as it assesses productivity, performance, and effectiveness w.r.t other models/methods which focus only on performance as in [21], [22], [36], Decision-support w.r.t. [42], Comprehensiveness w.r.t [4], [19], [42], [45], [46] which focuses either on Indonesia, Europe, Colombia, India, Brazil, other countries solely, Required time w.r.t [24] for example which utilizes other indicator types than time of completion, and Intention to use w.r.t [24] for example which missing its presence. Also, the analytical findings of the study have several implications for future research since the absence of a globally agreed upon definition of SC. The BSSC-ML contributes to 1) better understanding of what constitutes a SSC and its measurement, 2) paves the way to a carry on research, 3) comprehensiveness w.r.t to the inclusion of interviews, KPIs, and was validated and evaluated, 4) generalizability as it can be utilized to any SC worldwide if dictated precisely, and 5) the model bridges gaps in the literature and contributes to the SC field.

VI. Conclusions

Sustainability is becoming a goal of future smart city (SC) developments of several developing countries to meet the UN sustainable development goals (SDGs) w.r.t. the environmental, social and economic dimensions of sustainable smart cities (SSC). In regard of Economic sustainability, there exist several Economic assessment models of SSC' MLs which are based on the analysis and measurement of Technology/ICT MLs but their characteristics, mechanisms, and adaptations demonstrated severe deficiencies. In this study, an EA based BSSC-ML tool was developed aiming to monitor the long-term planning progress of the Economic SSC ML by analyzing and measuring the MLs of the Enabling Technology/ICT capabilities as a prerequisite to assessing the Economic SSC's MLs. The BSSC-ML facilitates the 1) classification of enabling Technology/ICT capabilities, 2) measurement of the MLs of the Technology/ICT capabilities based on of 20 indicators, and 3) assessment of MLs of the Economic SSC based on of 30 KPIs. A DSR method was utilized to guide the development, assessment, and evaluation of the BSSC-ML artifact. The data collection and analysis of the classified Enabling Technological/ICT capabilities were performed based on semi- structured interviews, reviewing of secondary data, and recent web content analysis of official portals. A Delphi technique was utilized to evaluate the model and the findings revealing promising acceptance scores of 88.123%. The study described the development process of BSSC-ML for SSC' Economic MLs assessment at which the evaluation scores proved its effectiveness as a monitoring too for local and global SCs.

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ORCID:
Ehab J. Adwan: https://orcid.org/0000-0001-9526-4065

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