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SIMURG_CITIES: Meta-Analysis for KPI's of Layer-Based Approach in Sustainability Assessment

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ABSTRACT

SIMURG_CITIES, is the research and development project that is developed under the main project named as SIMURG: "A performance-based and Sustainability-oriented Integration Model Using Relational database architecture to increase Global competitiveness of Turkish construction industry in industry 5.0 era", is the relational database model that is currently being developed in a dissertation for performance-based development and assessment of sustainable and sophisticated solutions for the built environment. This study aims to analyze the key performance indicators (KPIs) at «Cities Level» for the smart city concept that is referred to as «Layers» in the master project. KPIs for the concept of a smart city is determined by using the meta-analysis technique. Hence, the three most reputable urban journals issued from 2017 through 2020 are reviewed in this study. In addition to this, models of smart city frameworks/assessment tools/KPIs are reviewed within the context of this paper; environment, economy and governance were found to have domain themes on the urban sustainability according to the literature review. Consequently, efficient and integrated urban management, environmental monitoring and management, public and social services of urban development and sustainability are found to be the most important dimensions in urban and regional planning. SIMURG_CITIES evaluation models for urban projects can use the findings of this paper.

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1. Introduction

With globalization, individuals living within the same community which are of the different demographics structure and understanding of life have increased and also lifestyles and expectations of these individuals have changed. The characteristics of built

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environment-related value systems have differentiated utilizing individuals' age, culture, educational level, etc. Nevertheless, policy makers (individuals/companies/institutions/local authorities) have designed living spaces uniformly assuming there is a single type of individual according to their value systems. While policy makers are preparing urban policies, cities continue to grow depending on rent since there are no tools to help rational decision making and decision support systems that can be measured. At this point, performance-based design and building of built environments to evaluate alternatives in a comparative way seems to have increased attractiveness for individuals/companies/institutions/local authorities of policy makers. As a result of the examinations made, it has been concluded that the model which will be developed for the solution of the identified problem must include and reveal the components of the solution in the dimensions stated by Kanoğlu et al. (2018).

The United Nations (UN) assumed seventeen Sustainable Development Goals (SDGs) that are aimed to "stimulate action over the next 15 years in areas of critical importance for humanity and the planet" in the last publication of the global sustainable development agenda, "Transforming Our World: The 2030 Agenda for Sustainable Development". Features as part of the targets referred to 3rd goal on "good health and well-being", 4th goal on "quality education", 8th goal on "economic growth", 9th goal on "innovation and infrastructure", and 11th goal on "sustainable cities and human settlements" (United Nations, 2015). *Sustainability* is the main concept among those that can be achieved by the integrated use of the other key concepts which are *innovation, competitiveness, competition by design, performance-based building production process, integration of building production processes and interoperability supported by BIM (Building Information Modelling) and information classification systems* (Kanoğlu et al., 2018). These concepts seem to be the key factors to design an integrated model that increases the competitive advantage of the national construction industry in the global market. Additional concepts that are not of less importance compared with the first set are transparency, accountability and consistency. What the individuals, institutions, companies and society need in Turkey are the practical and accessible tools that provide these concepts at all levels of decision-making. The problem is the lack of these tools that allow the governments and municipalities to propose suitable identities defined by the concepts or "layers" such as historical/smart/green/slow/safe/resilience etc, that are presented by specific KPIs and associated weights, for their built environments at all levels and to develop consistent policies for this purpose that helps individuals in matching up their attributes with social, cultural, economic, educational, etc., characteristics of the built environment they are supposed to live. Many more sub-components such as management, planning, energy, transportation, infrastructure resources, etc. of cities are needed to make a sustainable performance-based assessment, as well as KPI's set, should be determined from its parameters for the design to be aesthetic, compatible with user needs and functions.

SIMURG: "A performance-based and *S*ustainability-oriented *I*ntegration *M*odel *U*sing *R*elational database architecture to increase *G*lobal competitiveness of the Turkish construction industry in industry 5.0 era" is integrated with the subprojects conducted by Kanoğlu et al. (2018) within the SIMURG_ALKU&ITU Virtual Laboratory, established on the Research Gate Scientific Communication Platform (https://www.researchgate.net/profile/Alaattin_Kanoglu). Kanoğlu et al. (2018) designed the open-ended project that improvement for concerned models at all hierarchical levels of "performance-based design and construction" of the built environment manner in various sub-projects in two supplementary fields, i.e., "product" and "process" dimensions. "Building components", "building elements", "building premises", "buildings", "projects", "lands", "quarters", "settlements", "counties" and "cities" levels on "product side" and "operations", "projects", "departments", "firms", "groups of firms", "sectors", "national economies" and "global economy" levels on "process side" are the hierarchical levels of these dimensions. All the levels are required, specific KPIs and weights are determined together with organisational, computational and computer models are designed. SIMURG_CITIES, the relational

database model that is currently being conducted by Ülker under the supervision of Kanoğlu et al. (2018) in her dissertation entitled SIMURG_CITIES: "A Performance-Based Integrated Model for Design and Evaluation of Sustainable and Sophisticated Solutions at Cities Level: Determination of Key Performance Indicators and Principles of Model at Conceptual Dimension". The main goal of the project is to determine the KPIs of performance of built environments at the city level in terms of the combinations of level-specific and layer/concept specific KPIs in both expert and user point of views and integrate the findings with SIMURG_INTEGRATED, the final output of the master project. This paper aims to analyse and determine the KPIs at "Cities Level" for the smart concept that is referred to as "Layers" in the master project. Also, the other aim of the paper is to review Models of smart city frameworks/assessment tools/KPIs on urban development and sustainability owing to the literature review.

2. Materials and Methods

The conceptual framework of this research is based upon an analysis of KPIs for the smart city concept. Meta-analysis is used to make a classification of the literature in the study. It also purposes to allow for a better understanding of the smartness of an urban framework acquired with the augmented use of sustainable thinking, particularly regarding urban studies. Hence, at first, this research demonstrates the descriptions of concepts and hypothetical basics of smart cities. Literature review link to the papers and researches is submitted, with the keywords "smart cities" or "smart city" and its integration with terms regarding urban planning and city assessment/framework/performance indicator/KPI. The literature review on the background of the sustainability approach indicated that research referring in related to the urban framework is based on the headings of "smart cities" or "digital cities". The research was carried out through a search of libraries and scientific databases, particularly Taylor & Francis Online, Scopus, Science Direct, Web of Science and the most respected urban journals, Cities, Journal of Urban Technology, Sustainable Cities and Society for the period of 2017-2020 to gather information and systematically review the hypothetical literature. As a result, fifty relevant papers were selected from these journals to analyse, determine and categorize the concept of smart cities and their KPIs. The writers, subjects and the methodologies of the reviewed fifty papers are presented in Table 1 and 2. The purpose is to allow for better practical and accessible tools/performance-based assessment that provides this concept in all levels of decision-making in the future.

Table 1. Papers associated with KPIs of Smart City that have been issued in Urban Literature during 2017-2020.

Writers	Year	Journal	Subject	Research Methodology
Lam & Yang	2020	Cities	PPP for SC projects	Multi-attribute utility analysis
Wataya & Shaw	2019	Cities	Measuring soft assets in SCs development	Co-value creation evaluation
Molinillo et al.	2019	Cities	Measurement of SC communication via SM	Digital content analysis
Montalto et al.	2019	Cities	Measurement of cultural vitality of ECs	An empirical approach
Huovila et al.	2019	Cities	Standardized indicators for sustainable SCs	Comparative analysis
Lam & Ma	2019	Cities	Identifying potential pitfalls in SCs development	An exploratory study
Heaton & Parlikad	2019	Cities	Infrastructure assets in SC framework	A conceptual framework
Shmelev & Shmeleva	2019	Cities	Multidimensional sustainability assessment for SC	Performance benchmarking
Yigitcanlar et al.	2018	Cities	Multidimensional sustainability assessment for SC	A systematic literature review
Ruhlandt	2018	Cities	Governance of SCs	A systematic literature review
Anthopoulos	2017	Cities	Performance analysis of international SC cases	A multi-methods approach
Navarro et al.	2017	Cities	ICT use and capability on SCs	Component analysis
Ahvenniemi	2017	Cities	Assessment framework for sustainable SCs	Performance benchmarking

Gessa & Sancha	2020	Journal of Urban Technology	Assessment framework for environmental in SC	Multiple case study research
Kiuru & Inkinen	2019	Journal of Urban Technology	E-Capital and economic growth in urban areas	An empirical approach
Costa-Liberato et al.	2018	Journal of Urban Technology	Digital Technology in Smart Tourism	A case study research
Falco et.al.	2018	Journal of Urban Technology	"Infostructure" approach to urban mobility	A case study research
Yigitcanlar & Kamruzzaman	2019	Journal of Urban Technology	SCs and Mobility	Multiple regression analysis
Fernandez-Anez et al.	2018	Journal of Urban Technology	Assessment framework of SC projects	Multiple case study research
Deal et al.	2017	Journal of Urban Technology	Urban resilience and planning support systems	A systematic literature review
Wong et al.	2017	Journal of Urban Technology	Knowledge structures of City ISs	Multiple case study research
Pak et al.	2017	Journal of Urban Technology	Socio-Demographic inequality in CP	A descriptive analysis
Joss et al.	2017	Journal of Urban Technology	Smart Citizen	A discourse analysis

PPP: Public-Private Partnerships, SC: Smart City, SM: Social Media, ECs: European cities, Iss: Innovation Systems, CP: Civic participation.

Table 2. Papers associated with KPIs of Smart City that have been published in Urban Literature from 2017 to 2020 (continued).

Writers	**Year**	**Journal**	**Subject**	**Research Methodology**
Yang et al.	2020	Sustainable Cities and Society	Smart Transportation	A coupled simulation method
Shapsough et al.	2020	Sustainable Cities and Society	Smart Energy	Performance measurement
Tang et al.	2020	Sustainable Cities and Society	Smart Transportation	Machine learning methods
Deveci et al.	2020	Sustainable Cities and Society	Assessment framework of SC projects	Interval Agreement Method
Sáez et al.	2020	Sustainable Cities and Society	Sustainbale City performance	Performance benchmarking
Sharifi	2020	Sustainable Cities and Society	SC assessment tools and indicator sets	Performance measurement
Yigitcanlar et al.	2019	Sustainable Cities and Society	Smart and sustainable cities	A systematic literature review
Karji et. al.	2019	Sustainable Cities and Society	Assessment of Social Sustainability Indicators	A case study research
Ghofrani et al.	2019	Sustainable Cities and Society	Smart building	Neural Networks approach
Akande et al.	2019	Sustainable Cities and Society	Smart Sustainbale City performance	Component analysis
Horgan & Dimitrijević	2019	Sustainable Cities and Society	Smart Citizen	A case study research
Nitoslawski et al.	2019	Sustainable Cities and Society	Smart Environment	A literature review
Walnum et al.	2019	Sustainable Cities and Society	Smart Energy	Multi-attribute decisionmaking
Mattoni et al.	2019	Sustainable Cities and Society	Smart Energy	Performance measurement
Zhu et al.	2019	Sustainable Cities and Society	Smart Energy	Machine learning methods
Michalec et al.	2019	Sustainable Cities and Society	Smart Environment	A discourse analysis
Zhang et al.	2018	Sustainable Cities and Society	Performance Evaluation for Smart Transportation	TOPSIS, A case study
Manupati et al.	2018	Sustainable Cities and Society	Urban renewal under SCs mission	Multi-criteria decision making
Ahmad & Chan	2018	Sustainable Cities and Society	Smart Energy	Machine learning methods
Silva et al.	2018	Sustainable Cities and Society	Sustainable SCs	A literature review
Alkhalidi et al.	2018	Sustainable Cities and Society	Smart Environment	The energy evaluation method

Aghamolaei et al.	2018	Sustainable Cities and Society	Performance Evaluation for Smart Energy	The energy evaluation method
Dall'O' et al.	2017	Sustainable Cities and Society	SC assessment tools and indicator sets	Performance measurement
Bibri & Krogstie	2017	Sustainable Cities and Society	Sustainable SC assessment tools/indicator sets	A systematic literature review
Hukkalainen et. Al.	2017	Sustainable Cities and Society	Smart Energy	Holistic energy analysis
Poggi et al.	2017	Sustainable Cities and Society	Performance Evaluation for Smart Energy	A case study research
Massana et al.	2017	Sustainable Cities and Society	Performance Evaluation for Smart Energy	A case study research

PPP: Public-Private Partnerships, SC: Smart City, SM: Social Media, ECs: European cities, Iss: Innovation Systems, CP: Civic participation.

3. Results: Meta-Analysis for KPI's of Layer-Based Approach in Sustainability Assessment

This section elaborates on the reviewed fifty papers in the literature and seven key themes and forty-four sub-themes/dimensions which are referred to in the last studies by Sharifi (2019, 2020) for the smart city assessment. The "typology of smart city evaluation tools and indicator sets" of Sharifi (2019, 2020) is used as a base for the meta-analysis table. Specific KPIs determined for each paper were marked in the meta-analysis table according to relevant themes or sub-themes/dimensions which were conducted topics in the papers. The findings of the meta-analysis are indicated in Table 3, 4 and 5 that show the ratings of themes and sub-themes/dimensions related KPIs of a smart city in urban literature. The rating of seven themes for related KPIs of the smart city in the literature (Table 6), the major result of this research is that; environment, economy, governance-institutional and data management is found to be the most important themes in urban and regional planning. Besides, the themes which are people, living and mobility (transport & ICT) need to become as important as the other themes.

Table 3. Themes and Sub-themes of the reviewed papers on Urban Literature.

Sharifi (2019) Assessment Tools & KPIs for Smart Cities		Relevant Studies for KPIs in Literature (2017-2020)																	
Theme	**Dimension**	Lam & Yang (2020)	Wataya & Shaw (2019)	Molinillo et al. (2019)	Montalto et al. (2019)	Huovila et al. (2019)	Lam & Ma (2019)	Heaton & Parlikad (2019)	Shmelev & Shmeleva (2019)	Yigitcanlar et al. (2018)	Ruhlandt (2018)	Anthopoulos (2017)	Navarro et al. (2017)	Ahvenniemi (2017)	Gessa & Sancha (2020)	Kiuru & Inkinen (2019)	Costa-Liberato et al. (2018)	Falco et.al. (2018)
Economy	Innovation/innovation culture		√		√	√		√	√	√	√	√	√	√		√	√	
	Knowledge economy		√			√		√	√	√		√	√	√		√	√	
	Entrepreneurship				√	√		√	√	√	√	√	√	√		√		
	Finance	√				√		√	√	√		√	√	√		√		
	Tourism			√		√			√	√		√	√	√		√	√	
	Employment				√	√		√	√	√		√	√	√		√	√	
	Local & Global Interconnectedness	√			√	√			√	√		√	√	√		√		
	Productivity and efficiency		√			√		√	√	√	√	√	√	√		√		
	Flexibility of the labor market				√	√		√	√	√		√	√	√		√		
	Impacts	√	√		√	√			√	√		√	√	√		√		√
People	Education/ lifelong learning		√		√	√	√	√	√	√		√	√	√		√		
	Level of qualification/ ICT skills		√	√	√	√	√	√	√	√		√	√	√		√		√
	Cosmopolitanism/ open mindedness		√		√	√		√	√	√		√	√	√		√		
Governance -institutional	Visioning and leadership	√	√			√	√	√	√	√	√	√	√	√			√	√
	Legal and regulatory frameworks		√		√	√	√		√	√	√	√	√	√				
	Participation		√		√	√	√	√	√	√	√	√	√	√				
	Transparency	√	√		√	√			√	√	√	√	√	√				√
	Public and social services	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√

	Efficient & integrated urban management	√	√			√	√		√	√	√	√	√	√			√	√
Environment	Environmental monitoring & management	√				√		√	√	√	√	√	√	√	√			√
	General infrastructure	√			√	√			√	√		√	√	√	√			√
	Built environment/planning and design				√	√			√	√		√	√	√	√			
	Materials					√			√	√		√	√	√	√			
	Energy resources	√				√			√	√		√	√	√	√			
	Water resources	√				√			√	√		√	√	√	√			
	Waste (solid waste, waste water, sewage)	√				√			√	√		√	√	√	√			
	Environmental quality/pollution	√				√			√	√		√	√	√	√			
Living	Social cohesion/inclusion		√	√	√	√		√	√	√		√	√	√			√	√
	Equity and justice		√		√	√		√	√	√		√	√	√				
	Cultural development		√		√	√		√	√	√		√	√	√			√	
	Housing/livelihood quality					√		√	√	√		√	√	√				
	Healthcare	√				√		√	√	√		√	√	√				
	Safety and security	√				√		√	√	√		√	√	√				√
	Convenience and satisfaction/ well-being		√		√	√		√	√	√	√	√	√	√			√	√
Mobility (Transport & ICT)	Transport infrastructure				√	√			√	√		√	√	√				√
	Transportation management	√	√			√	√		√	√	√	√	√	√			√	√
	ICT infrastructure					√	√		√	√		√	√	√			√	√
	ICT management		√			√	√		√	√	√	√	√	√			√	√
	ICT accessibility				√	√	√		√	√		√	√	√			√	√
Data management	Data openness	√	√			√			√	√	√	√	√	√	√			√
	Sensing and collecting	√	√			√		√	√	√	√	√	√	√	√			√
	Judging (analytics)	√	√			√			√	√	√	√	√	√	√			√
	Reacting	√	√			√		√	√	√	√	√	√	√	√			√
	Learning	√	√			√			√	√	√	√	√	√	√			√

Table 4. Themes and Sub-themes of the reviewed papers in Urban Literature (continued).

Sharifi (2019) Assessment Tools & KPIs for Smart Cities		Relevant Studies for KPIs in Literature (2017-2020)																
		Yigitcanlar & Kamruzzaman (2019)	Fernandez-Anez et al. (2018)	Deal et al. (2017)	Wong et al. (2017)	Pak et al. (2017)	Joss et al. (2017)	Yang et al. (2020)	Shapsough et al. (2020)	Tang et al. (2020)	Deveci et al. (2020)	Sáez et al. (2020)	Sharifi (2020)	Yigitcanlar et al. (2019)	Karji et. al. (2019)	Ghofrani et al. (2019)	Akande et al. (2019)	Horgan & Dimitrijević (2019)
Theme	**Dimension**																	
Economy	Innovation/innovation culture		√		√		√					√	√		√		√	
	Knowledge economy		√			√						√	√				√	
	Entrepreneurship		√									√	√		√		√	
	Finance		√								√	√	√		√		√	
	Tourism		√									√	√				√	
	Employment		√		√						√	√	√		√		√	
	Local & Global Interconnectedness		√									√	√		√		√	
	Productivity and efficiency	√	√		√		√		√	√	√	√	√	√	√	√	√	√
	Flexibility of the labor market		√									√	√				√	
	Impacts		√								√	√	√		√	√	√	√
People	Education/ lifelong learning		√				√					√	√				√	√
	Level of qualification/ ICT skills	√	√	√		√	√					√	√				√	√
	Cosmopolitanism/ open mindedness		√				√					√	√				√	√
Governance-institutional	Visioning and leadership	√	√	√	√	√					√	√	√	√	√		√	√
	Legal and regulatory frameworks		√									√	√				√	√
	Participation		√				√					√	√				√	√

	Transparency		√									√	√				√	√	
	Public and social services		√	√	√	√	√	√	√		√	√	√			√	√	√	√
	Efficient & integrated urban management	√	√	√	√	√	√	√	√	√	√	√	√			√	√	√	√
Environment	Environmental monitoring & management		√		√	√	√	√	√		√	√	√	√	√	√	√	√	√
	General infrastructure		√					√	√		√	√	√			√	√	√	
	Built environment/planning and design		√			√		√	√			√	√			√	√	√	
	Materials		√			√		√	√			√	√			√	√	√	
	Energy resources		√					√	√		√	√	√			√	√	√	
	Water resources		√					√	√			√	√			√	√	√	
	Waste (solid waste, waste water, sewage)		√						√		√	√	√			√	√	√	
	Environmental quality/pollution		√					√	√		√	√	√			√	√	√	
Living	Social cohesion/inclusion	√	√			√	√					√	√					√	
	Equity and justice		√				√		√			√	√					√	
	Cultural development		√				√					√	√					√	
	Housing/livelihood quality		√				√					√	√					√	
	Healthcare		√				√					√	√					√	
	Safety and security		√				√					√	√			√		√	
	Convenience and satisfaction/ well-being	√	√			√	√				√	√	√			√	√	√	√
Mobility (Transport & ICT)	Transport infrastructure	√	√					√	√	√	√	√	√	√	√			√	
	Transportation management	√	√	√	√		√	√	√	√	√	√	√	√	√			√	
	ICT infrastructure	√	√	√		√			√	√	√	√	√	√	√	√	√	√	
	ICT management	√	√	√	√	√			√	√	√	√	√	√	√	√	√	√	
	ICT accessibility	√	√	√	√	√			√	√	√	√	√	√	√	√	√	√	
Data management	Data openness	√	√	√	√			√	√	√	√	√	√	√				√	
	Sensing and collecting	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
	Judging (analytics)	√	√	√	√	√		√	√	√	√	√	√	√				√	
	Reacting	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
	Learning	√	√	√	√	√		√	√	√	√	√	√	√				√	

Table 5. Themes and Sub-themes of the reviewed papers in Urban Literature (continued).

Sharifi (2019) Assessment Tools & KPIs for Smart Cities		Relevant Studies for KPIs in Literature (2017-2020)																	
Theme	**Dimension**	Nitoslawski et al. (2019)	Walnum et al. (2019)	Mattoni et al. (2019)	Zhu et al. (2019)	Michalec et al. (2019)	Zhang et al. (2018)	Manupati et al. (2018)	Ahmad & Chan (2018)	Silva et al. (2018)	Alkhalidi et al. (2018)	Aghamolaei et al. (2018)	Dall' O' et al. (2017)	Bibri & Krogstie (2017)	Hukkalainen et. Al. (2017)	Poggi et al. (2017)	Massana et al. (2017)	**Total for dimensions**	**Total for themes**
Economy	Innovation/innovation culture							√					√	√				22	219
	Knowledge economy							√		√			√	√				19	
	Entrepreneurship							√					√	√				18	
	Finance							√		√			√	√				19	
	Tourism							√					√	√				18	
	Employment							√					√	√				20	
	Local & Global Interconnectedness							√					√	√				17	
	Productivity and efficiency	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	40	
	Flexibility of the labor market							√					√	√				16	
	Impacts	√		√	√	√		√	√	√	√	√	√	√	√	√		32	
People	Education/ lifelong learning	√						√					√	√				21	68
	Level of qualification/ ICT skills	√					√	√					√	√				27	
	Cosmopolitanism/ open mindedness	√						√					√	√				20	
Governance -institutional	Visioning and leadership					√	√	√		√	√	√	√	√	√	√	√	36	184
	Legal and regulatory frameworks							√					√	√				18	
	Participation	√	√	√	√	√	√	√		√			√	√				27	
	Transparency							√					√	√				19	
	Public and social services		√	√	√	√		√				√	√	√	√	√		40	
	Efficient & integrated urban management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	44	
Environment	Environmental monitoring & management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	41	264
	General infrastructure	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	34	

	Built environment/planning and design	√	√	√	√	√		√	√	√	√	√	√	√	√	√	32	
	Materials	√	√	√	√	√		√	√	√	√	√	√	√	√	√	31	
	Energy resources	√	√	√	√	√		√	√	√	√	√	√	√	√	√	32	
	Water resources	√	√	√	√	√		√	√	√	√	√	√	√	√	√	31	
	Waste (solid waste, waste water, sewage)	√	√	√	√	√		√	√	√	√	√	√	√	√	√	31	
	Environmental quality/pollution	√	√	√	√	√		√	√	√	√	√	√	√	√	√	32	
Living	Social cohesion/inclusion							√					√	√			22	148
	Equity and justice							√					√	√			18	
	Cultural development							√					√	√			18	
	Housing/livelihood quality							√					√	√			15	
	Healthcare							√		√			√	√			17	
	Safety and security							√		√	√	√	√	√			21	
	Convenience and satisfaction/ well-being		√	√	√	√	√	√	√	√	√	√	√	√	√		√	37	
Mobility (Transport & ICT)	Transport infrastructure						√	√		√		√	√	√	√			26	163
	Transportation management			√	√		√	√		√		√	√	√	√			35	
	ICT infrastructure	√		√	√	√	√	√		√		√	√	√				32	
	ICT management	√		√	√	√	√	√		√		√	√	√			√	36	
	ICT accessibility	√		√	√	√	√	√		√		√	√	√				34	
Data management	Data openness	√			√	√		√		√		√	√	√			√	32	180
	Sensing and collecting	√			√	√		√	√	√		√	√	√	√	√	√	40	
	Judging (analytics)	√			√	√		√	√	√		√	√	√			√	34	
	Reacting	√			√	√		√	√	√		√	√	√	√	√	√	40	
	Learning	√			√	√		√	√	√		√	√	√			√	34	

Table 6. Ratings of 7 Key Themes for related KPIs of Smart City in Urban Literature

Themes	Ratings
Environment	264
Economy	219
Governance-institutional	184
Data management	180
Mobility (Transport & ICT)	163
Living	148
People	68

Table 7. Highest and lowest 10 ratings of Dimensions for related KPIs of Smart City in Urban Literature.

Dimensions	Ratings	Dimensions	Ratings
Efficient & integrated urban management	44	Housing/livelihood quality	15
Environmental monitoring & management	41	Flexibility of the labor market	16
Public and social services	40	Tourism	16
Productivity and efficiency	40	Healthcare	17
Reacting	40	Local & Global Interconnectedness	17
Sensing and collecting	40	Cultural development	18
Convenience and satisfaction/ well-being	37	Legal and regulatory frameworks	18
ICT management	36	Equity and justice	18
Visioning and leadership	36	Entrepreneurship	18
Transportation management	35	Finance	19

The highest and lowest ten ratings of forty-four dimensions for related KPIs of a smart city in the literature review are defined in Table 7. The other critical result of this research is efficient and integrated urban management, environmental monitoring and management, public and social services, productivity and efficiency and data management in urban development and sustainability are found to be the highest important dimensions. However, housing/livelihood quality, the flexibility of the labour market, smart tourism and smart healthcare are found to be the lowest ratings of dimensions. Smart/sustainable city planning has been revealed for development the lives of urban citizens and for increasing civic

services/assets; also, given the closeness of modern technology, citizens' requirements and tools of interacting with their regional administrations is changing (Nitoslawski et al., 2019). At this critical point of changing, cultural development, innovation and entrepreneurship are the main dimensions to be considered. Since, culture is a concept that social, emblematic and economic implications can mention people's customs, religions and attitude, or economic activities based on symbolic values, artistic creation and creative skills also are a key for involved improvement, strengthening social ties and solidarity, and promoting innovation and creativity (Montalto et al, 2019).

4. Discussions

Modern cities tackle with numerous economic, social and spatial troubles, together with which they perform in an extremely volatile environment, which pushes them to seek an optimum development model. Nowadays, countless concepts/models (such as eco/ green/ compact/ smart/ slow/ resilient/ agile/ sustainable city etc.) of urban development have been discussed by researchers. In this section, the model/concept of smart city frameworks/performance indicators/assessment tools is researched and discussed in detail in the literature.

Cities act a crucial part in socioeconomically and environmentally at a global level. The city infrastructure appeals to numerous people looking at the advantages of urbanisation over the conventional rural lifestyles inside various cultural contexts. The United Nations (UN) estimates that almost 7 billion people will inhabit in urban fields by 2050 (Streitz, 2015). Some other 1.3 million people around the world move into a city every week (Carter, 2020). Consequently, cities and their executives are meeting myriad difficulties and opportunities as their facilities and infrastructure are placed under ever enhancement levels of pressure (Breetzke and Flowerday, 2016). A rising trend is that manage the impact of these difficulties and opportunities in the usage of Information and Communication Technology (ICT) among an accessible integrated infrastructure for a concept of smart city (Ismagilova et al., 2019). Numerous cities are focusing their struggles to be "smarter" by using ICT to develop different ways of city management and operation, including regional traffic control, offer upscale life for people, transportation, economy, on-line applications of public services and environment (Li et al., 2017). The smart cities are innovation for the improvement of targets in the quality of life and development by the utilization of smarter approaches and technology (Lim et al., 2019). Smart cities have been researched extensively for almost three decades and there are many ways of looking at them. Smart city studies first arose in the year of 1992 in which "The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks" (Gibson et al., 1992). Then, Graham and Marvin (1996) began the research of the link between ICTs and urban fields with "Telecommunications and the City". Some studies in this recent field of knowledge are form Mitchell, 1995, 1999, 2003; and Castells, 1996). In the early 2000s as the best efficient research was "urban ICT studies", Graham (2004) accomplished to research "the complex and poorly understood set of relationships between telecommunications and the development, planning and management of contemporary cities". In the study of ICT-driven urban development and innovation have engaged the attention of researchers (Mora et al., 2017). The key centre of smart cities is on the act of ICT infrastructure. The plenteous environmental concerns as a significant motive of urban development at the part of relational/social capital and education/human capital (Komninos, 2002; Shapiro, 2008; Deakin, 2010).

Many definitions for "Smart Cities" in use globally, but smart city defines as "a new concept and a new model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data and space/geographical information integration, to facilitate the planning, construction, management and smart services of cities" according to SAC (ISO/IEC 2015). In literature, meanwhile, there is not any certain description of a smart city, a few basic dimensions of a smart city have been described (Giffinger et al., 2007; Fusco Girard et al., 2009; Van Soom, 2009). These dimensions cover "smart" governance/environment/mobility/economy/living/people. Briefly, "education" (e.g. e-governance or e-democracy), "technical infrastructure" (e.g. transportation or logistic), "industry" (e.g. business parks or districts), "participation" (e.g. government

administration, citizens), and various "soft factors" (e.g. security/safety, green, efficient and sustainable energy) are defined in the literature regarding smart city (Giffinger et al. 2007; Lombardi et al. 2012). In addition to them, Anthopoulos (2015) and Anthopoulos et al., (2016) have defined seven utilization areas of smart cities: "resource, transportation, urban infrastructures, living, government, economy, and coherency" thus they founded theoretical structure of smart cities. While academics maintain to qualify smart cities as a recent and up-and-coming subject of research, the study of conceptualising and describing is still on-going (Townsend, 2013; Kitchin, 2014; Christopoulou et al., 2014; Greco and Cresta, 2015; Albino et al., 2015; Fernandez-Anez, 2016). On the other hand, the technology-focused vision of smart cities generally positions smart city like a cash cow and expects to produce a lot of money (Zanella et al., 2014). This rising market provides an opportunity for various growth initiatives, especially in a period of recession (Paroutis et al., 2014), big firms such as ABB, Fujitsu, IBM apply information and communication technologies as tools for smart-city development to motivate urban innovation. Nevertheless, this "corporate smart-city model" is condemned since it has not successfully explained the cultural and social developments of smart-city manner except for technological terms (Mora et al., 2017). Regarding this censure, Shin (2010) showed the failure of this model empirically and highlighted the shortcomings of the firm and technology-focused development for smart cities. Likewise, Shwayri (2013), Townsend (2013), Yigitcanlar & Lee (2014) and Yigitcanlar (2016) reported in some samples of these smart cities. On the other hand, from the recent studies, a holistic approach of smart cities has risen to base on human-centric vision ovation, the balanced integration of economic, social, cultural, technological, environmental, and human sides (Townsend, 2013; Hemment and Townsend, 2013; Komninos, 2014; Christopoulou et al., 2014; Angelidou, 2014; Concilio and Rizzo, 2016; Hollands, 2015, 2016). After all, Mora et al., 2017 have underlined that "the knowledge necessary to understand the process of building effective smart cities in the real world has not yet been produced, nor have the tools for supporting the actors involved in this activity". In a nutshell, smart cities have factors such as "community", "technology", "policy"; the inclusive conceptual vision of the framework centres on finding the results in the development areas, i.e., "economy", "society", "environment", "governance" which are associated with five results "productivity", "sustainability", "accessibility", "wellbeing", "liveability", "governance" (Yigitcanlar et al., 2018). In addition to them, Sharifi (2019, 2020) has examined the strengths and weaknesses by evaluating thirty-four topics/schemes between smart city indicators. The results have shown that the widely known topics/themes are: "economy", "people", "governance", "environment", "mobility", "living" and "data".

5. Conclusions

SIMURG_CITIES, the relational database model of performance-based development and evaluation of built environment entities at cities level with an emphasis of "sophisticated solutions" such as slow, green, safe, smart, resilient, etc. in a comparative way have been developed. This study analysed the KPIs at «Cities Level» for smart city concept by using meta-analysis technique and literature reviewed that has been issued in three best reputable urban journals from 2017 through 2020. Environment, economy, governance and data management were found to have domain themes, as well as efficient and integrated urban management, environmental monitoring and management, public and social services in urban development and sustainability, are found to be the highest important dimensions of urban and regional planning. In addition to these, smart tourism, smart healthcare, smart people, smart transportation as well as the dimensions of cultural development, innovation, creativity and entrepreneurship are also open to development. This detailed study presents a crucial understanding of the key basic research topics/themes in smart cities, emphasizing the restrictions of latest improving and potential further aspects. The results of this research might be used in SIMURG_CITIES to assess/evaluate urban development models by related target groups such as smart city policy makers/planners/developers to prefer best appropriate tools for their requirements, can be used as a foundation for performing future crucial analyses of assessment/evaluation framework, may also lead the performance-based development

and assessment of sustainable and sophisticated solutions in the future.

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Conflict of interests
The Authors declare no conflict of interest.

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