A Smart City Adoption Model to Improve Sustainable Living

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Abstract

In recent years, there has been a growing trend of large population of people moving towards urban living. As estimated that by 2030 more than 60 percent of the world population will live in urban geographical location, as more than half of the world's population currently resides in urban areas. Such complex and enormous inhabitation of people certainly tend to become disordered. Thus, safeguarding livable conditions to be in line with rapid worldwide urban population increment requires an extensive knowledge of smart city initiatives. But, currently stakeholders, decision makers and city planners/developers are faced with inadequate information regarding the dimensions of smart city required to achieve sustainable living. Thus, in achieving smart cities there is need for decision makers and city planners/developers to make strategic decisions on how to adopt smart city initiatives. Hence, there is need to identify the smart city dimensions and associated initiatives to be adopted by policy makers in implementing smart city policies. Therefore, this study identifies the smart city dimensions (smart economy, smart people, smart governance, smart mobility, smart environment, and smart living) and further develops a smart city adoption model to assess the current smart city initiatives being implemented. Moreover, data was collected from 115 respondents using survey questionnaire to empirically validate the proposed smart city adoption model. Accordingly, Partial Least Square-Structural Equation Modelling (PLS-SEM) was employed to analyze the collected data. Results from the analyzed survey data confirms the identified smart city dimension are applicable in facilitating smart city adoption.

Keywords: *Sustainable living; Smart city dimensions; Smart city initiatives; Urban development; City planning; Information system.*

1. Introduction

Smart city is an international trend of urban policies aimed at improving citizens quality of life residing in urban areas by leveraging modernization and deploying technologies to address the issues generated by highly dense population (Moreno et al., 2017). Smart city notion aims to address issues of urbanization, especially land consumption, pollution of environmental, energy needs, transport congestion. Moreover, smart city entails a diversified set of initiatives for developing better transportation systems for innovative energy-saving policies (Su et al., 2011). According to Khan et al. (2017) smart city aims to deploy innovative devices to improve knowledge economy, environmental conservation, and technological progress. Over the years the concept of smart city has been gaining increased attention around the world (Jnr et al., 2019), and is emerging as a response to address the challenges faced by cities such as increasing population, severe budget reductions, climate change, environmental degradation, etc. (Jnr et al., 2018).

Thus, initiatives such as the European Union (EU) smart cities agenda provide novel horizons for innovation. Several projects such as the Lighthouse Smart Cities programs have started to navigate the next generation of smart reduced carbon solutions for cities (Badii et al., 2017). While, the term smart city has gained acceptance in recent years, a widely established definition is yet to exist. Accordingly, a city is said to be smart when investments in Information Communication Technology (ICT), social and human capital, sustainable economic growth, modern transport, supports a high quality of life which also upholds the management of natural resources (Chourabi et al., 2012; Junior et al., 2018). Likewise, a city is smart when it resolves the issues of pollution, energy overconsumption, crowding, sprawl, waste, crime, traffic congestion, etc. Furthermore, smart city addresses the urban problems in supporting citizen quality of live improvement, upholding sustainability and involving citizens through transparent governance policies (Deakin, 2012). Similarly, smart city intensively deploys ICT to collect, analyze and disseminate information to transform facilities and services, enhance operational efficiency and involves better decisions (David et al., 2012).

Accordingly, to safeguard livable conditions to be in line with rapid worldwide urban population increment requires an extensive knowledge of smart city initiatives (Wolfram, 2012). Furthermore, based on the urgency around these issues many cities around the world are looking for smarter ways to manage city planning (Su et al., 2011). But, due to high subjectivity, uncertainty, and complexity of smart city planning development, which is a domain where expert knowledge is often hard to extract and/or represent by an approach which require to present information regarding smart city as explicit, definite, and generalized knowledge (Yigitcanlar, 2015). Likewise, it is time consuming for stakeholders, city planners, and city developers to search information regarding how smart city initiatives are to be successfully adopted (Moreno et al., 2017). Hence, stakeholders, decision makers and city planners/developers are faced with inadequate information regarding the dimensions of smart city required to achieve sustainable living (Badii et al., 2017).

Therefore, in achieving a smart city there is need for decision makers and city planners/developers to make strategic decisions on how to implement smart city dimensions. Hence, there is need to identify the smart city dimensions to be adopted by policy makers in implementing smart city for sustainability attainment (David et al., 2012). Similarly, there are smart city initiatives that is required to be explored by both academicians and practitioners in fostering sustainable development. Likewise, there is lack of an approach to act as a mediator between policy makers and city planners in helping to make decision on smart city dimensions preference (Anthony et al., 2018). Therefore, this study identifies the dimensions to be adopted by policy makers, city planners, and city developed in achieving a smart city and further develops a smart city adoption model to assess the current smart city initiatives being implemented. The rest of the paper is structured as follows Section 2 is the literature review, the proposed model is presented in Section 3. Methodology is outlined in Section 4, results and discussion is presented in Section 5, and conclusion is presented in Section 6.

2. Literature Review

This section presents the theoretical background of smart city by presenting the overview of smart city and smart city dimensions.

2.1. Overview of Smart Cities

Smart city comprises of comprehensive and integrated aspects of urban life to improve health care, economy, culture, governance, transport, and green areas (Gaur et al., 2015). The specific features of a smart city consist of consolidating and creating innovation and knowledge (Moreno et al., 2017). Thus, smart city initiatives help to increase economic and social competitiveness and attractiveness of a city sustained by its technological infrastructure. Smart city entails a complex urban environment that incorporates several technology and systems, human behavior, economy, social and political structures (Jnr et al., 2018). Specifically, a smart city utilizes ICT to optimize the effectiveness and performance of needful and serviceable city processes, services and activities usually by linking up diverse constituents and actors into a faultlessly collaborating intelligent system (Su et al., 2011). Accordingly, Figure 1 depicts smart city components and related initiatives;

Figure 1 Smart city components and initiatives adopted from Giffinger and Gudrun (2010)

Figure 1 depicts an example of a smart city solution that entails important components that improves sustainable development. Thus, smart city provides an intelligent approach to manage components such as energy, transport, buildings, health, and homes towards safeguarding the environment (Azkuna, 2012). Respectively, smart city solutions involve an effective integration of smart planning ideas, smart development approaches, smart management methods, and smart construction modes (Moreno et al., 2017).

2.2.Smart City Dimensions

Researchers such as Giffinger et al. (2007); Giffinger and Gudrun (2010) identified six main components which comprises of smart economy, smart mobility, smart environment, smart people, smart living, and smart governance as seen in Figure 2.

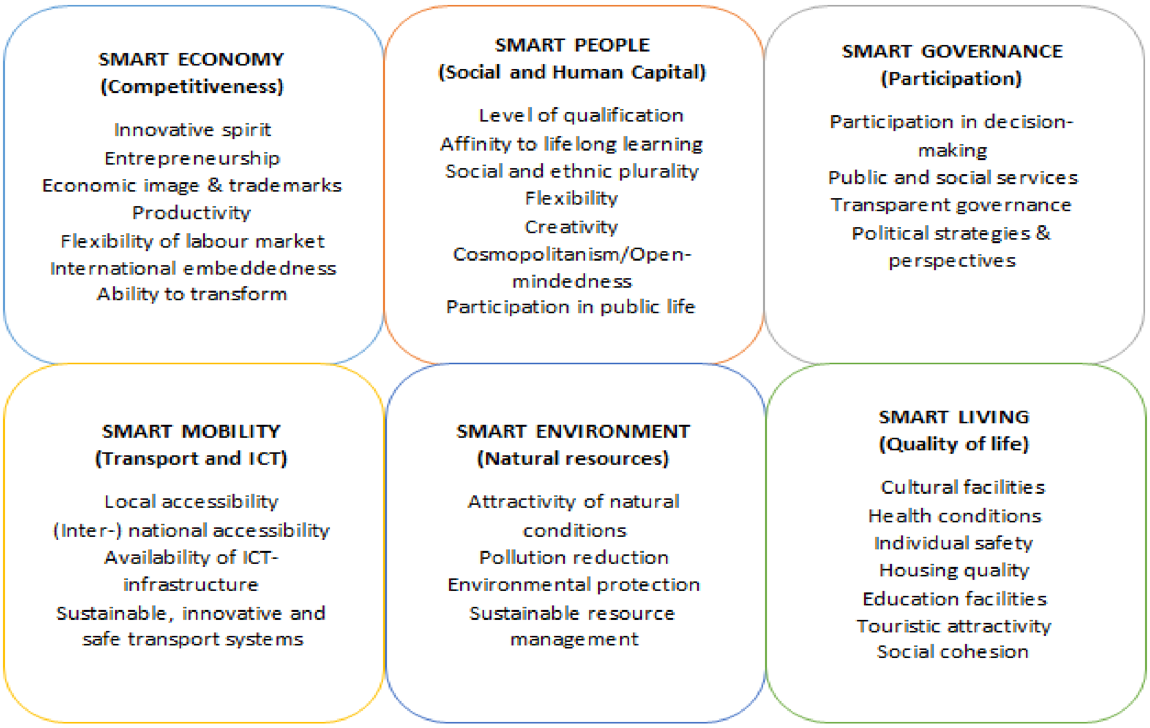

Figure 2 Smart city dimensions and indicators (Giffinger and Gudrun, 2010).

Figure 2 depicts the dimensions of smart city, accordingly each of the identified dimensions are discussed below;

2.2.1. Smart Economy

The smart economy relates to cities with smart industries, particularly in the application of ICT as well as other sectors that involve ICT in their manufacturing and construction processes (Giffinger and Gudrun, 2010).

2.2.2. Smart Living

Smart living involves several features that significantly enhance the quality of life of residents, such as health, culture, housing, tourism, safety, etc. Thus, improving each of these features leads to a more harmonious, satisfactory, and fulfilled life (Giffinger et al., 2007; Azkuna, 2012).

2.2.3. Smart Environment

Smart environment refers to the utilization of novel technologies to preserve and protect a city's natural environment (Jnr et al., 2018). Smart environment is categorized by trust and security, deployment of ICT to enhance municipal safety, cultural initiatives for the digitization of tradition assets (Azkuna, 2012).

2.2.4. Smart Mobility

Smart mobility involves providing the inhabitants with access to new and innovative technologies, which involves the use of these technologies in routine urban life (Giffinger et al., 2007). The available infrastructure should support the ability for all citizens to process and share information instantaneously from any location within the city commuting (Azkuna, 2012).

2.2.5. Smart Governance

Smart governance includes active and political participation, residency services and the utilization of e-government (Marciniak and Owoc, 2013). Besides, it often relates to the deployment of innovative technologies, such as e-democracy or e-government (Giffinger et al., 2007).

2.2.6. Smart People

Smart people involve the distinguishing component between digital cities (Azkuna, 2012). The inhabitants are smart in terms of their educational levels and skill, as well as the value of social collaboration in terms of incorporation of public life and their capability to communicate with other countries (Madkour et al., 2013).

Based on the derived components as reviewed in Section 2.2. it is evident that smart city is a trend of urban policies aimed at improving the quality of citizens residing in urban areas by leveraging the modernization and deploying technologies to address the issues generated by highly dense population (Moreno et al., 2017). Specifically, smart city utilizes ICT to optimize the effectiveness of needful and serviceable city processes usually by linking up diverse constituents and actors into a faultlessly collaborating intelligent system (Su et al., 2011). All these characteristics are integrated with wider ideas including social improvement, economic viability, and environmental protection.

3. Proposed Model

Based on the dimensions for smart cities identified from prior studies (Giffinger et al., 2007; Giffinger and Gudrun, 2010; Azkuna, 2012; Madkour et al., 2013; Marciniak and Owoc, 2013; Moreno et al., 2017; Jnr et al., 2018). Accordingly, as presented in Figure 2 the smart city comprises of smart economy, smart mobility, smart environment, smart people, smart living, and smart governance as independent variables and smart city adoption as dependent variable. Grounded on these dimensions from the literature this study develops the proposed smart city adoption model as seen in Figure 3.

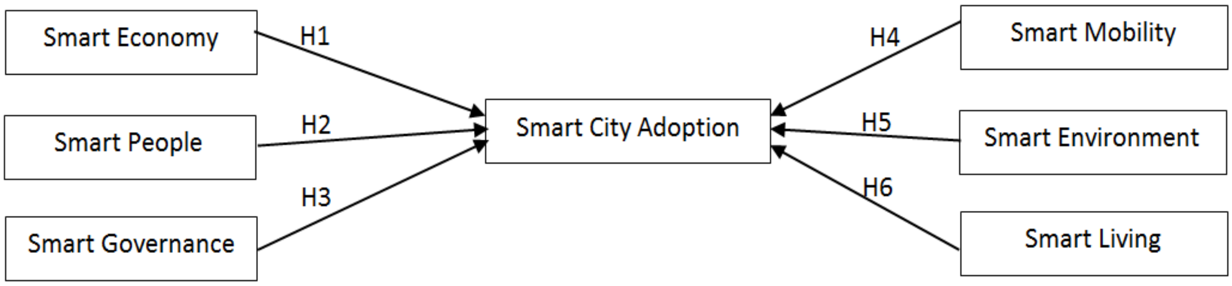

Figure 3 Conceptualized smart city model

Figure 3 depicts the conceptualized smart city model that comprises of the smart city dimensions that is to be implemented by city planners/developers in adopting smart city. Based on the model the following hypotheses H1-H6 are derived as presented below;

H1: Smart economy initiatives positively determine smart city adoption.

H2: Smart people involvement positively influences smart city adoption.

H3: Smart governance policies initiatives positively predict smart city adoption.

H4: Smart mobility initiatives positively determine smart city adoption.

H5: Smart environmental initiatives positively influence smart city adoption.

H6: Smart living initiatives positively determine smart city adoption.

The proposed model presents the identified dimensions of smart city to be adopted in achieving a sustainable living. Furthermore, the proposed model provides information as best practices on smart city initiatives previously implemented in other regions to serve as guidelines to stakeholders, city planners, and developers (see Figure 2).

4. Methodology

This study adopts a quantitative research approach and the research flow adopted for this study is presented in Figure 4.

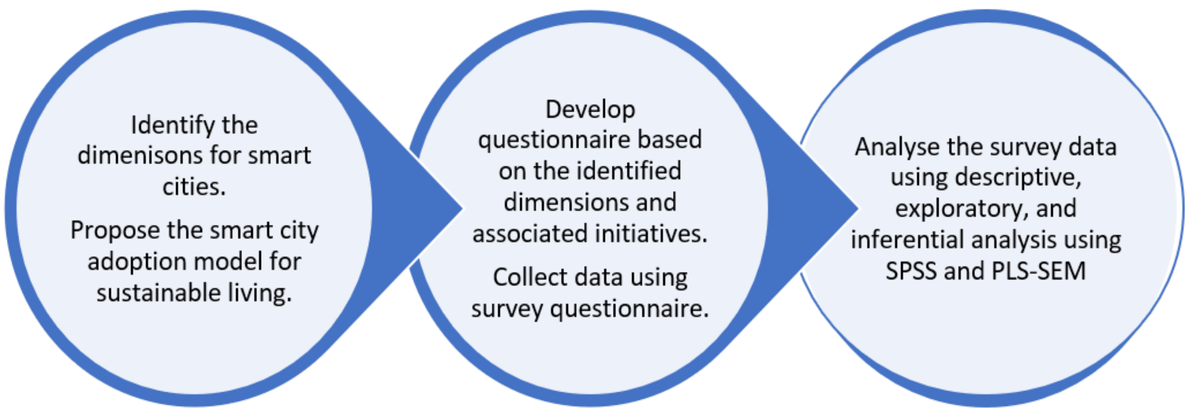

Figure 4 Research flow

Figure 4 depicts the research flow which begins by identifying the dimensions for smart cities as seen in Figure 2 followed by the proposed smart city adoption model shown in Figure 3. In the next phase survey questionnaire was developed based on the identified dimension and related initiatives. Purposive sampling was employed to collect data from respondents who have experience in smart city and sustainable initiatives. The survey questions are designed to verify the identified dimensions of smart city for smart city planning development for city planners, developers and decision makers. Therefore, the survey instrument questions are developed based on prior research studies on smart city. The survey questions are divided into two sections; section one consists of demographic characteristics of the respondents. The second part comprises of questions (see appendix) to confirm the dimensions of smart city using a Likert scale with five response categories (1-5) was used where "1" indicates strongly disagree and "5" represents strongly agree.

Accordingly, data was collected from 115 respondents to validate the smart city dimensions derived from the literatures and was analyzed using descriptive, exploratory, and inferential statistics in Statistical Package for Social Science (SPSS) version 23 and Partial Least Square-Structural Equation Modelling (PLS-SEM). PLS-SEM method is a variance-based method that supports path analysis of dimensions or variables in a model using SmartPLS software utilized to analyze the data. We opted for PLS-SEM in this study because it is considered as an inclusive statistical technique that supports simultaneous modification and evaluation of research model which examines the correlation among dimensions. In addition, PLS-SEM is suitable for models that consist of a several hypotheses. PLS-SEM carries out two main analyses; the first is the assessment of the measurement model assessed by checking the descriptive, validity, and reliability. Secondly, it involves inferential analysis which is the analysis of the paths relationship (hypotheses) of the model.

4.1. Descriptive Analysis

Descriptive analysis is used to describe the data collected in research studies and to accurately characterize the items under observation within a specific sample. Descriptive statistics provides information about the overall representativeness of the sample, as well as the information necessary for other researchers to replicate the study (Anthony Jr et al., 2018). In this research mean, standard deviation, minimum, maximum, and normality (Skewness and Kurtosis) results from SPSS is used to assess the importance of each item used to rate the dimensions of smart city.

4.2. Exploratory Analysis (Validity and Reliability)

Exploratory statistics entails validity and reliability, where validity refers to the degree in which the questionnaire instrument measure what is intended to measure. In this study, validity is determined by measuring the items loadings, convergent validity (Average Variance Extracted (AVE)) and discriminate validity. Likewise, reliability refers to degree to which the measure of concept is stable or if the measurement procedure yields consistent results over extended time frame (Hair et al., 2016). The Cronbach's alpha is used to measure the internal consistency reliability coefficient and it ranges from 0-9, where "> 0.9 – Excellent, > 0.8 – Good, > 0.7 – Acceptable, > 0.6 – Questionable, > 0.5 – Poor and < 0.5 – Unacceptable". The reliability is measured using Cronbach's Alpha and Composite Reliability (CR).

4.3. Inferential Analysis

Inferential statistics is employed to test the dimensions of smart city. In this study PLS-SEM is utilized for test of structural model and test of assessment model to confirm the dimensions. Hence, descriptive, exploratory, and inferential analyses are used in this study for statistical analysis of the survey questionnaire data in validating the proposed model (see Figure 3).

5. Results and Discussion

5.1. Demographic Statistics

This sub-section presents results from the first part of the questionnaire; thus, the demographic characteristics of the survey respondents are illustrated in Table 1.

Table 1 Demographic characteristic of survey respondents

Profile	Options	Frequency	Percentage
Gender:	Male	50	43.5%
	Female	65	56.5%
Age:	< 25	1	0.90%
	25-34	41	35.7%
	35-44	56	48.7%
	45-55	16	13.9%
	>55	1	0.90%
Highest Qualification:	Diploma	4	3.50%
	Bachelor's degree	29	25.2%
	Master's degree	43	37.4%
	Doctorate	26	22.6%
	Professional certificate	13	11.3%
Current Position:	Sustainability Expert	44	38.3%
	City Planner	56	48.7%
	City Developer	2	1.70%
	ICT Expert	2	1.70%
	Smart City Expert	11	9.60%
	Others	44	38.3%
Employment Category:	Governmental	57	49.6%
	Non-governmental	56	48.7%
	Private	2	1.70%
Employment Type:	Temporal	110	95.7%
	Contract	1	0.90%
	Permanent	4	3.50%
Experience in Smart City (Please Specify in Years)	Less than 1 year	30	26.1%
	1-2 years	29	25.2%
	3-4 years	34	29.6%
	5-6 years	13	11.3%
	More than 6 years	9	7.80%
Area of Smart City Specialization:	Smart Economy	42	36.5%
	Smart People	56	48.7%
	Smart Governance	2	1.70%
	Smart Mobility	2	1.70%
	Smart Environment	2	1.70%
	Smart Living	11	9.60%

Table 1 depicts the demographic data of the 115 survey respondents measured using ordinal scale. The results are presented in frequency and percentage. The respondents are purposively selected since they have prior knowledge on smart city and sustainability issues, thus they are selected to provide data on the validation of the smart city components derived from the literature.

5.2. Descriptive Analysis

The descriptive analyses comprise of maximum, minimum, mean, standard deviation, Skewness, and Kurtosis values of the smart city dimensions as seen in Table 2. SPSS was employed to check the descriptive statistics for all smart city dimensions. Results from Table 2 show the minimum and maximum response form from the respondents based on the 5-point Likert scale. Moreover, results from Table 2 indicate that the mean values are higher than 2.5 based on a 5-point scale. Besides, results for standard deviation show a narrow spread between the mean indicating that the responses from the respondents are close, and not widely dispersed (Anthony Jr et al., 2018). The data was also screened to confirm normality by checking the Skewness and Kurtosis values. The values of the Skewness and Kurtosis for the items were between the recommended cutoffs of 3.0 for Skewness and 8.0 for Kurtosis as recommended by Teo (2019).

Table 2 Descriptive analysis of smart city dimensions

Smart City Dimension	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	**Kurtosis**
Smart Economy	3	5	3.90	0.754	0.075	-1.442
Smart People	3	5	3.95	0.792	-0.036	-1.571
Smart Governance	3	5	3.90	0.765	-0.004	-1.494
Smart Mobility	2	5	3.69	0.734	0.215	-0.979
Smart Environment	2	5	3.59	0.713	0.315	-0.962
Smart Living	2	5	3.55	0.684	0.493	-0.923
Smart City Adoption	1	5	3.22	0.843	-0.061	0.081
Note: For Mean 1 = least effective; 2 = fairly-effective; 3 = effective; 4 = very effective; and 5 = most effective The recommended cut-offs are 3.0 for Skewness and 8.0 Kurtosis as recommended by Teo (2019)						

5.3.Exploratory Analysis (Convergent Validity and Reliability)

The reliability and validity were assessed, where the reliability refers to the degree to which the variables give consistent results and are free from errors. Likewise, validity refers to the extent to which a variable/dimension differs from other variables in the same model in measuring what it supposed to measure (Anthony Jr et al., 2018). In assessing the model (see Figure 5) results from Table 3 depicts the questionnaire items loadings, Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE).

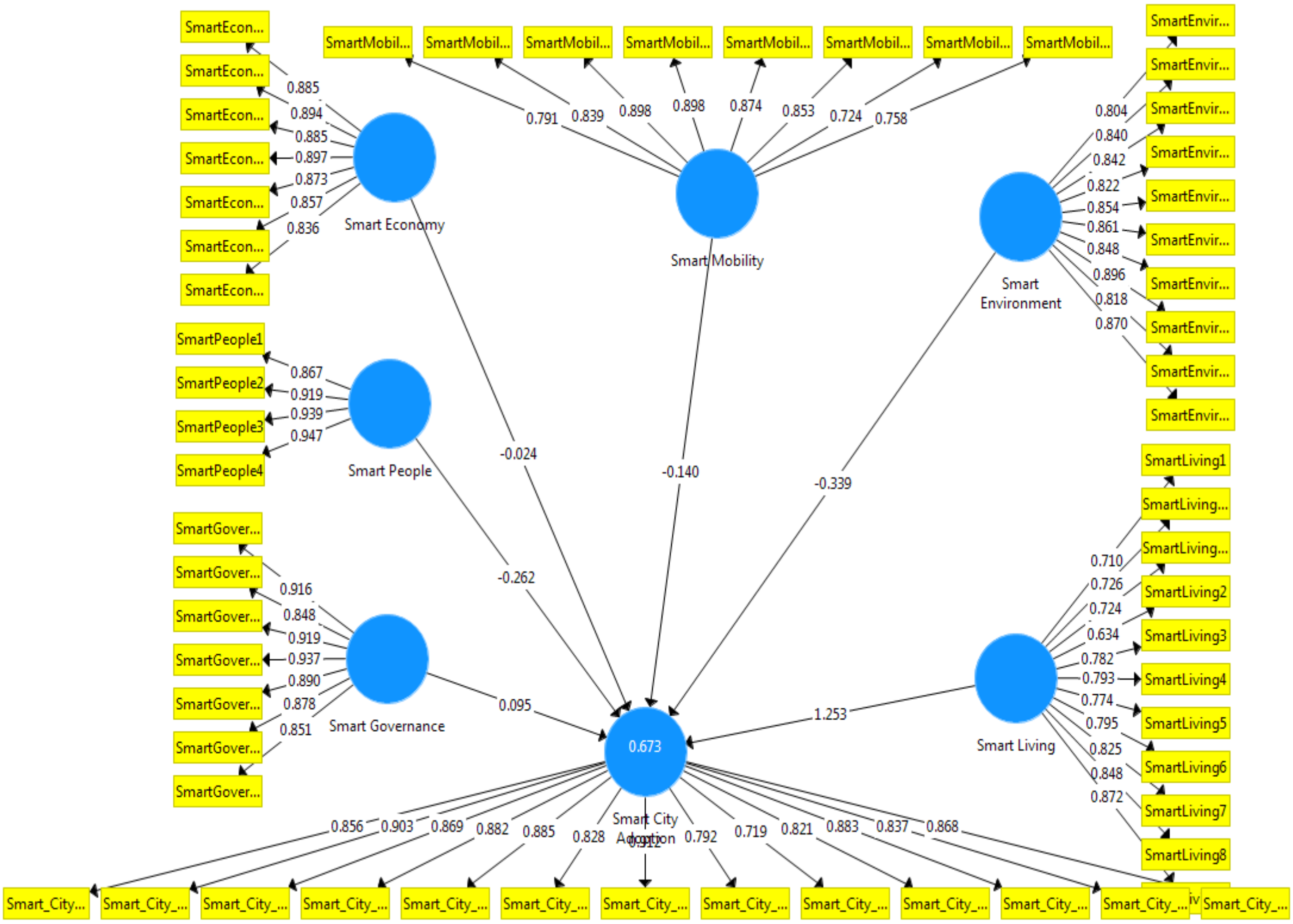

Figure 5 PLS-SEM analyses of the smart city model

Table 3 Reliability and validity analyses of smart city dimensions

Smart City Dimensions	**Items**	**Loadings**	**Cronbach's Alpha (α)**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
Smart Economy	SE1	0.885	0.950	0.958	0.766
	SE2	0.894			
	SE3	0.885			
	SE4	0.897			
	SE5	0.873			
	SE6	0.857			
	SE7	0.836			
Smart People	SP1	0.867	0.938	0.956	0.843
	SP2	0.919			
	SP3	0.939			
	SP4	0.947			
Smart Governance	SG1	0.916	0.957	0.965	0.795
	SG2	0.848			
	SG3	0.919			
	SG4	0.937			
	SG5	0.890			
	SG6	0.878			
	SG7	0.851			
Smart Mobility	SM1	0.791	0.936	0.947	0.692
	SM2	0.839			
	SM3	0.898			
	SM4	0.898			
	SM5	0.874			
	SM6	0.853			
	SM7	0.724			
	SM8	0.758			
Smart Environment	EN1	0.804	0.957	0.962	0.716
	EN2	0.840			
	EN3	0.842			
	EN4	0.822			
	EN5	0.854			
	EN6	0.861			
	EN7	0.848			
	EN8	0.896			
	EN9	0.818			
	EN10	0.870			
Smart Living	SL1	0.710	0.938	0.942	0.599
	SL2	0.726			
	SL3	0.724			
	SL4	0.634			
	SL5	0.782			
	SL6	0.793			
	SL7	0.774			
	SL8	0.795			
	SL9	0.825			
	SL10	0.848			
	SL11	0.872			
Smart City Adoption	SCR1	0.856	0.968	0.972	0.726
	SCR2	0.903			
	SCR3	0.869			
	SCR4	0.882			
	SCR5	0.885			
	SCR6	0.828			
	SCR7	0.912			
	SCR8	0.792			
	SCR9	0.719			
	SCR10	0.821			
	SCR11	0.883			
	SCR12	0.837			
	SCR13	0.868			

Thus, PLS-SEM was employed to measure the reliability and validity of the smart city dimensions as seen in Figure 5 and Table 3. Accordingly, results from Figure 5 and Table 3 suggest that items loaded exceed the minimum threshold of 0.4 as is recommended (Hair et al., 2016; Teo, 2019). In addition, results in Table 3 show the reliability measure based on the Composite Reliability (CR) and Cronbach's alpha score which should be greater than 0.70 for CR and Cronbach's alpha (Hair et al., 2016). Besides, convergent validity, which specifies that a set of items corresponds to one and the same underlying variable, was assessed as seen in Table 3 based on the values of the Average Variance Extracted (AVE) which should be greater than 0.50 denoting that a variable is able to explain more than 50% variance of its items (Fornell and Larcker, 1981; Hair et al., 2016).

5.4.Discriminate Validity

Discriminant validity relates to the level of difference between the sets of smart city dimensions and their own items or initiatives. In this regard, Hair et al. (2016) mentioned that the correlations between items in two dimensions should not be higher than the square root of the mean variance shared by a single dimension's items. To assess for discriminant validity, the Fornell and Larcker (1981) test was employed, where this test checks if the square root of AVE of each dimension exceeds the correlation shared between the dimension and other dimensions in the model (see Figure 3). Moreover, the AVE value should be greater than 0.50 for all dimensions measuring 50% variance (Anthony Jr et al., 2018). Results from Table 4 indicate that all smart city dimensions acceptably higher than 0.5 and the square root of the AVE (on the diagonal) are larger than the cross-correlations with other dimensions.

Table 4 Discriminate validity of smart city dimensions

Dimensions	Smart City Adoption	Smart Economy	Smart Environment	Smart Governance	Smart Living	Smart Mobility	Smart People
Smart City Adoption	**0.852**						
Smart Economy	0.210	**0.875**					
Smart Environment	0.476	0.660	**0.846**				
Smart Governance	0.288	0.844	0.753	**0.892**			
Smart Living	0.743	0.558	0.85	0.658	**0.774**		
Smart Mobility	0.367	0.674	0.816	0.812	0.736	**0.832**	
Smart People	0.253	0.865	0.729	0.921	0.64	0.757	**0.918**

5.5.Inferential Analyses (Hypotheses Testing)

This is the final step which involves test of the model which confirms the hypotheses (H1-H6). Accordingly, the model hypotheses are tested by deploying PLS algorithm in SmartPLS 3.0 based on bootstrap re-sampling performed to examine the path significance levels of each hypothesis. Results from Table 5 depicts the hypotheses testing, where statistical significance of each hypothesis was assessed based on a two-tail test (***). Additionally, the structural model assessment is measured by examining the path coefficients value *(β)* which evaluates the association between variables based on their degree of significant levels *(p-value)* which is significant when $p=<0.05$. Moreover, the coefficient of determination termed R^2 value is used to measure the predictive significance of the model hypotheses. Next, *t-value* is employed to assess the effects of each hypothesis, which is based on the regression coefficients and associated significances as listed in Table 5 and Figure 6, where *t-value* should be greater than 1.96 in a two-tail test (Hair et al., 2016).

Table 5 Results of hypotheses (H1-H6)

Hypotheses	Path Description	Standard Error (SE)	Path Coefficient Beta (β)	R^2	t-value	Significance level (p-value)	Results
H1	Smart Economy -> Smart City Adoption	0.103	0.189	0.036	2.041	0.044	Supported
H2	Smart People -> Smart City Adoption	0.097	0.240	0.058	2.629	0.010	Supported
H3	Smart Governance -> Smart City Adoption	0.100	0.273	0.074	3.015	0.003	Supported
H4	Smart Mobility -> Smart City Adoption	0.101	0.346	0.119	3.916	0.000	Supported
H5	Smart Environment -> Smart City Adoption	0.100	0.439	0.193	5.199	0.000	Supported
H6	Smart Living -> Smart City Adoption	0.087	0.659	0.433	9.293	0.000	Supported
Decision: Hypothesis is supported if t-value = > 1.96 and p-value = <0.05							

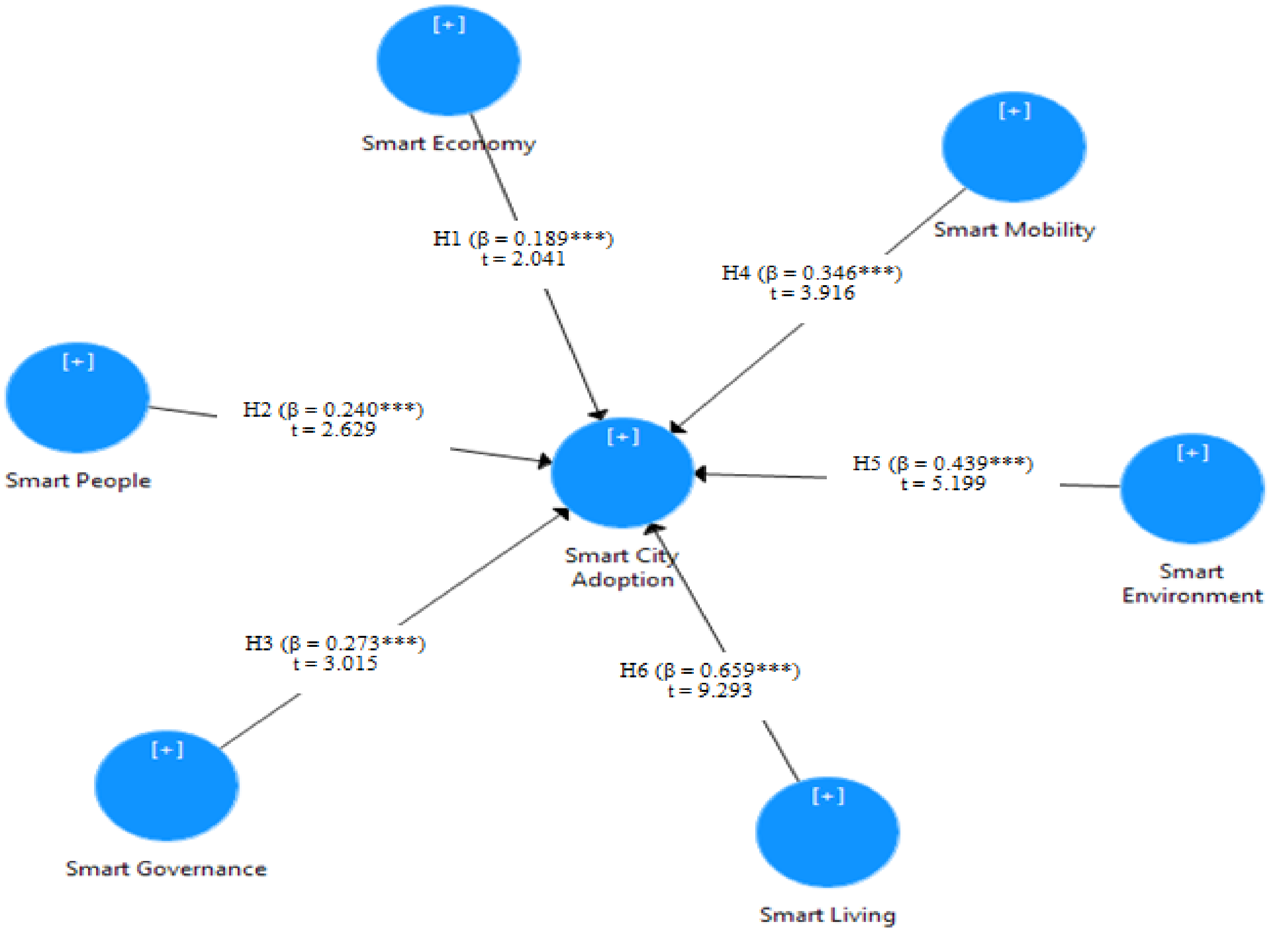

Figure 6 Final PLS-SEM results of the smart city model

Results from Table 5 and Figure 6 show the hypotheses test using a two-tailed t-test with a significance level of 5% (0.05). As seen all *t-values* are higher than 1.96. Furthermore, results from Table 5 also depict the β and R^2 values which is the different path coefficients ranking of the hypotheses, where H6 has the strongest effect of 0.659(0.433), followed by H5 with 0.439(0.193), then H4 with 0.346 (0.119), next is H3 with 0.273 (0.074), then H2 with 0.240(0.058), and lastly is H1 with 0.189(0.036). Therefore, the hypothesized path relationship (H1-H6) is statistically significant since β and R^2 values are greater than 0.1 and *p-values* are lower than 0.05 (Hair et al., 2016).

5.6. Discussion

This study identifies the smart city dimensions and further develops a smart city adoption model to assess the current smart city initiatives being implemented. Data was collected using a survey instrument and analyzed using PLS-SEM. Findings from this study indicate that smart economy initiatives positively determine smart city adoption. This may be reasoned to the fact that smart economy relates to a city driven by entrepreneurialism, innovation, labour market flexibility, and an improve degree of financial competitiveness (Giffinger et al., 2007). This result is consistent with findings from prior study (Tahir and Malek, 2016) where the authors mentioned that smart economies brings about competitiveness which is important not only for appealing investors, but also for attracting citizens to secure a key global position. Thus, an increase in economic growth will lead to growth in the city's ability to attract investment and corporations (Kumar and Dahiya, 2017).

The results of this study support the findings of previous works (Tahir and Malek, 2016; Mishra et al., 2017) that have shown that smart people positively determine smart city adoption. As stated by Anthopoulos et al. (2019) smart people refers to human and social capital as well as citizens participation towards city development. Thus, for a city to be smart there is need for its citizens to be truly innovative, inclusive, and environmental conscious. Respectively, in a smart city citizens empowerment is a major factor that play a vital role in improving city governance (Tahir and Malek, 2016). Furthermore, the results reveal that that smart governance initiatives positively influence smart city adoption. This result is in line with findings from previous studies (Giffinger et al., 2007; Anthopoulos et al., 2019), where that researchers stated that smart governance aims to improve future of public services and community leadership for continuous development through innovation. It involves the use of technology to aid efficiency agenda, better planning and decision making (Wolfram, 2012). Besides, it includes providing systematic updates on governance matters and promoting innovation in public service delivery. Additionally, it relates to improving the democratic and e-government processes towards transforming how public services are transparently delivered to citizens (Tahir and Malek, 2016).

Similarly, the results suggest that smart mobility positively influences smart city adoption. This finding is supported by Tahir and Malek (2016); Anthopoulos et al. (2019) due to the fact smart mobility relates to local accessibility of modern, safe, and sustainable transport systems. It entails the deployment of Information Technology (IT) to transform and revitalize the current transport routes within the city in creating fiscal opportunities and enhancing global competitiveness mobility (Tahir and Malek, 2016; Jr et al., 2017). Our results also indicate that smart environment initiatives positively predict smart city adoption. This is because smart environment involves the attractiveness of natural conditions of the city in relation to reduce pollution, and the sustainable use and management of natural resources (Anthopoulos et al., 2019). Moreover, it involves vital aspects of sustainability, such as the increased environmental protection, reducing of demands need for natural resources and energy efficiency (Kumar and Dahiya, 2017).

Lastly, the results reveal that smart living positively influence smart city adoption. This is in parallel with findings from the literature (Giffinger et al., 2007; Tahir and Malek, 2016) confirming that smart living aims to improve citizens quality of life by transforming residential areas, office, energy and transportation infrastructures into smart environments. Moreover, our results suggest that smart living enhances citizens understanding towards how people deploy technology in creating a sustainable environment. Evidently, smart living entails integrating all elements that contributes towards a happy and comfortable life to citizens by providing smart facilities and services enabled by the latest technology (Wolfram, 2012).

6. Conclusion

In recent years, there has been a growing trend of large population of people moving towards urban living. As estimated that by 2030 more than 60 percent of the world population will live in urban geographical location, as more than half of the world's population currently resides in urban areas. This shift from a mainly rural to a largely urban population is anticipated to continue for the next couple of years. Such complex and enormous inhabitation of people certainly tend to become disordered. Thus, safeguarding livable conditions to be in line with rapid worldwide urban population increment requires an extensive knowledge of smart city idea. Furthermore, based on the urgency around these issues many cities around the world are looking for smarter ways to manage sustainable living. Therefore, this study involves smart city adoption for sustainable living and proposes a model to investigate smart city adoption by identifying the smart city dimensions to be adopted. This study provides implications for cities by developing a set of smart city initiatives (see Appendix) that can be employed to assess the current smart city strategy in cities towards achieving sustainable living for their citizens.

Moreover, data was collected from respondents mainly city planners and sustainability experts using a designed survey instrument to validate the proposed model dimensions. Findings from this study presents the dimensions to be adopted by policy makers, city planners, and city developed in achieving a smart city. Likewise, findings from descriptive, exploratory and inferential analysis confirmed that the specified smart city dimensions are valid and applicable for providing recommending to improve smart city practice for cities in becoming a sustainable society. Furthermore, it is evident that all studies possess limitation(s) and this research is not an exception. Hence, in this study data was collected from only 115 respondents, where the sample size is acceptable for empirical study, however more data is required to be collected to increase the validity and robustness of the statistical results. In addition, data was collected from smart city experts, city planner, city developers, sustainability experts, IT experts, and other experts in a single country hence the results cannot be generalized to other countries. Accordingly, future work entails collecting data from respondents in other location to improve the generalization of the result.

References

Anthony Jr, B., Abdul Majid, M., & Romli, A. (2018). A collaborative agent based green IS practice assessment tool for environmental sustainability attainment in enterprise data centers. *Journal of Enterprise Information Management*, *31*(5), 771-795.

Anthony, B., Majid, M. A., & Romli, A. (2018). Green IS diffusion in organizations: a model and empirical results from Malaysia. *Environment, Development and Sustainability*, 1-42.

Anthopoulos, L., Janssen, M., & Weerakkody, V. (2019). A Unified Smart City Model (USCM) for smart city conceptualization and benchmarking. In *Smart Cities and Smart Spaces: Concepts, Methodologies, Tools, and Applications* (pp. 247-264). IGI Global.

Azkuna, I. (2012). Smart Cities Study: International study on the situation of ICT, innovation and Knowledge in cities. *Bilbao: the Committee of Digital and Knowledge-based Cities of UCLG.*

Badii, C., Bellini, P., Cenni, D., Difino, A., Nesi, P., & Paolucci, M. (2017). Analysis and assessment of a knowledge based smart city architecture providing service APIs. *Future Generation Computer Systems*, *75*, 14-29.

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., ... & Scholl, H. J. (2012). Understanding smart cities: An integrative framework. *45th Hawaii international conference on system sciences* (pp. 2289-2297).

David, B., Yin, C., Zhou, Y., Xu, T., Zhang, B., Jin, H., & Chalon, R. (2012). SMART-CITY: Problematics, techniques and case studies. In *2012 8th International Conference on Computing Technology and Information Management (NCM and ICNIT)* (Vol. 1, pp. 168-174).

Deakin, M. (2012). Intelligent cities as smart providers: CoPs as organizations for developing integrated models of eGovernment Services. *Innovation: The European journal of social science research*, *25*(2), 115-135.

Fornell, C., Larcker, D.F. (1981) Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res*. 18(1), 39–50.

Gaur, A., Scotney, B., Parr, G., & McClean, S. (2015). Smart city architecture and its applications based on IoT. *Procedia computer science*, *52*, 1089-1094.

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities?. *ACE: architecture, city and environment*, *4*(12), 7-26.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). Smart cities: Ranking of european medium-sized cities. vienna, austria: Centre of regional science (srf), vienna university of technology. *www. smart-cities. eu/download/smart_cities_final_report. pdf*.

Hair, J.F., et al. (2016). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Sage Publications, Thousand Oaks.

Jnr, B. A., Majid, M. A., & Romli, A. (2018). A Trivial Approach for Achieving Smart City: A Way Forward towards a Sustainable Society. *21st Saudi Computer Society National Computer Conference (NCC)* (pp. 1-6).

Jnr, B. A., Majid, M. A., & Romli, A. (2019). Green information technology adoption towards a sustainability policy agenda for government-based institutions. *Journal of Science and Technology Policy Management*. 10(2), 274-300.

Jr, B. A., Majid, M. A., & Romli, A. (2017). Green information technology system practice for sustainable collaborative enterprise: a structural literature review. *International Journal of Sustainable Society*, *9*(3), 242-272.

Junior, B. A., Majid, M. A., & Romli, A. (2018). Green information technology for sustainability elicitation in government-based organisations: an exploratory case study. *International Journal of Sustainable Society*, 10(1), 20-41.

Khan, Z., Dambruch, J., Peters-Anders, J., Sackl, A., Strasser, A., Fröhlich, P., ... & Soomro, K. (2017). Developing knowledge-based citizen participation platform to support Smart City decision making: The Smarticipate case study. *Information*, *8*(2), 47.

Kumar, T. V., & Dahiya, B. (2017). Smart economy in smart cities. In *Smart Economy in Smart Cities* (pp. 3-76). Springer, Singapore.

Madkour, M., Benhaddou, D., Khalil, N., Burriello, M., & Cline Jr, R. E. (2015). Living campus: towards a context-aware energy efficient campus using weighted case based reasoning. In *Workshops at the Twenty-Ninth AAAI Conference on Artificial Intelligence*.

Marciniak, K., & Owoc, M. L. (2013). Usability of Knowledge Grid in Smart City Concepts. In *ICEIS (3)* (pp. 341-346).

Mishra, A. P., Sen, A., & Kumar, A. (2017). Exploring Potentials and Challenges in Making Smart Cities in India: A Case Study of Allahabad City, Uttar Pradesh. In *Sustainable Smart Cities in India* (pp. 123-142). Springer, Cham.

Moreno, M. V., Terroso-Sáenz, F., González-Vidal, A., Valdés-Vela, M., Skarmeta, A. F., Zamora, M. A., & Chang, V. (2017). Applicability of big data techniques to smart cities deployments. *IEEE Transactions on Industrial Informatics*, *13*(2), 800-809.

Su, K., Li, J., & Fu, H. (2011). Smart city and the applications. In *2011 international conference on electronics, communications and control (ICECC)* (pp. 1028-1031).

Tahir, Z., & Malek, J. A. (2016). Main criteria in the development of smart cities determined using analytical method. *Planning Malaysia Journal*, *14*(5).

Teo, T. (2019). Students and Teachers' intention to use technology: Assessing their measurement equivalence and structural invariance. *Journal of Educational Computing Research*, *57*(1), 201-225.

Wolfram, M. (2012). Deconstructing smart cities: an intertextual reading of concepts and practices for integrated urban and ICT development (pp. 171-181).

Yigitcanlar, T. (2015). Smart cities: an effective urban development and management model?. *Australian Planner*, 52(1), 27-34.

Appendix (Questionnaire Items)

Smart City Dimensions	Initiatives (Items)	Reference
Smart Economy	SE1-Deployment of ICT use in businesses. SE2-Design strategies for the economic development of the city. SE3-Retaining and attracting talent and promoting creativity. SE4-Provide support for entrepreneurship. SE5-Development of business spaces and collaborations. SE6-Provide international promotion strategy for the city. SE7-Provision of tax payment system.	(Tahir and Malek, 2016; Kumar and Dahiya, 2017).
Smart People	SP1-Presence of a university in the city. SP2-Plans for ICT use and digital development in classrooms. SP3-Collaboration between companies and knowledge centres. SP4-Plan for research, development and innovation.	(Tahir and Malek, 2016; Mishra et al., 2017).
Smart Governance	SG1-Promoting ICT and innovation and online public services. SG2-Provide website availability for governance. SG3-Offers strategic plans to promote e-government. SG4-Administrative staff uses internet connected computers. SG5-Transparent governance and citizen participation. SG6-Implements e-democracy and electronic voting. SG7-Provison of birth and death registration.	(Tahir and Malek, 2016 ; Anthopoulos et al., 2019).

Smart Mobility	SM1-Provision of international accessibility. SM2-Availability of innovative and safe transport systems. SM3-Traffic management and parking system. SM4-Availability of bicycle tracks and unobstructed footpaths SM5-Deploy deal with ISPs to offer connectivity of ICT infrastructure. SM6-Provides Internet usage and broadband coverage. SM7-Provides mobile phone usage and mobile Internet. SM8-Provision of public internet access and Wi-Fi hotspots in cities.	(Giffinger and Gudrun, 2010; Jr et al., 2017).
Smart Environment	SEN1-Attractivity of natural conditions. SEN 2-Supports pollution reduction. SEN 3-Provides environmental protection. SEN 4-Provision of sewerage and waste water treatment. SEN 5-Adherence to the green practices and recycling of solid waste SEN 6-Promotes sustainable resource management. SEN 7-Using ICT to improve public safety. SEN 8-Initiatives for the digitization of heritage assets. SEN 9-Disaster prediction and early warning response system. SEN 10-Provision of fire stations disaster alarm system.	(Giffinger and Gudrun, 2010; Kumar and Dahiya, 2017).
Smart Living	SL1-Promotes utilization of ICT uses in homes. SL2-Promotes electronic health (e-health) policies. SL3-Provides on-line medical services. SL4-Provision of emergency response facilities s uh as ambulances, emergency and healthcare facilities. SL5-Offers remote home control or alarm systems for patients. SL6-Development of digital inclusion programme for groups at risk of exclusion. SL7-Guarantees individual safety and provides better housing quality. SL8-Promotes touristic attractivity and uphold social cohesion. SL9-Provision of 24/7 electric supply. SL10-Provision of 24/7 water supply. SL11-Provision of metering and online payment facility.	(Tahir and Malek, 2016; Kumar and Dahiya, 2017).
Smart City Adoption	SCR1- My city is actively involved for efficient functioning, management of city's sustainable development for more liveable. SCR2-My city highly values creativity and welcomes new ideas. SCR3- My city offers its citizens diverse economic opportunities. SCR4- My city focuses on the mobility of people, and not only that of vehicles. SCR5- My city advocates walkability and cycling. SCR6- My city conserves and preserves the ecological system in the city region. SCR7- My city efficiently and effectively manages its natural resource base. SCR8- My city focuses on water conservation and minimizes the unnecessary consumption of water. SCR9- My city has and continually upgrades its urban resilience to the impacts of climate change. SCR10- My city can create a low carbon environment with focus on energy efficiency, renewable energy. SCR11- My city has open and accessible public spaces. SCR12- My city has public services and amenities. SCR13- My city deploys e-governance for the benefit of all its residents.	(Giffinger et al., 2007; Tahir and Malek, 2016; Kumar and Dahiya, 2017).