

Survey on Sustainable Smart Cities Development: Challenges and Solutions

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ABSTRACT

This paper aims to presents the overview of research in the sustainable smart cities development domain. It investigates the key challenges of the sustainable smart cities development that faced by the developers from different countries. The qualitative research method via the interview is conducted to collect the data. 10 experts on the sustainable smart cities development project were interviewed in this study. The results indicate that there are 12 sustainable smart cities development challenges named: (1) budgetary constraint; (2) lack of resources; (3) lack of institutional capacity to deliver technology; (4) lack of systems integration; (5) social acceptability; (6) lack of awareness level in the smart city development among residents; (7) the need to drive towards content development; (8) lack of strategically approach in the smart city transformation; (9) disagreement on standardizing the smart city model; (10) lack of overarching institution to create the governance structure; (11) lack of sustainable focused strategies; and (12) lack of the smart city operational framework. Furthermore, the solutions framework for these challenges was proposed as the guidelines to overcome or minimize them.

Key Words: *Smart cities; Sustainability; Interview; Sustainable Development; Challenges; Policies*

1. INTRODUCTION

Sustainability is a principal concept that drives innovation and transformation on society [1-3]. It incorporates several challenges, such as urban development [4], energy management [5], information systems (IS) [6], waste management [7], and people's health and safety [8]. It has become the main interest in advanced cities and thus the smart city and Internet of Things (IoT) technologies can be the solutions to success in this field [9-10].

The IoT can be resulted from the advancement of the network connecting the zillions of attached gadgets [11]. For example, the technological improvements in ubiquitous computing (UC) [12], machine-to-machine (M2M) verbal exchange, and wireless sensors networks (WSN) have further supported the IoT belief [13-15]. Furthermore, the IoT have

been used in terms of warehouses [16], health [17], cities [18], and homes [19].

Literature shows that the smart cities is considered as one of the most important topic recently as the urbanization is considered all over the globe [20]. The sustainability and development of smart city is a progressive international policy issue [21]. Many governments have designed national plans for sustainable smart city development. For example, India has published its plans to develop its first smart city in 2015 and it plans to have 100 smart cities. In addition, Saudi Arabia in its 2030 vision plans to achieve its goal be considering 3 cities in kingdom from the best 100 smart cities in the world.

In order to reach these goals for building smart cities, there is several concepts have to be considered, such as strategies of government agencies, and infrastructure support, technology, and policies. Literature shows that there is several challenges can affect the success of the sustainable smart cities development and thus the stakeholders from the different 3 management level: operational, managerial, and executive level in the public and private sectors can play the role to overcome these challenges [22]. As a results, this article presents an overview of research in the sustainable smart cities development domain. It presents a review on the challenges that can affect the sustainable smart cities development. Also, we outline several guidelines to minimize these challenges and the possible further research directions in the sustainable smart cities development.

The remainder of this paper is organized as follows. Section 2 outlines the literature reviews. Section 3 presents the methodology that have been used to conduct this study. Section 4 reports the data analysis. Section 5 explains the main findings and discussion. Section 6 outlines the summary and recommendation for future works.

2. LITERATURE REVIEW

This section presents an overview of existing literature on the sustainable smart cities development.

2.1 Smart City Development

The Information and Communication Technology (ICT) application has contributed to the smart city development. According to that contribution, the smart cities can have several definitions. For example, the International Telecommunication Union (ITU) Focus Group on Smart Sustainable Cities has defined the smart city as the innovative city that may use the ICT in order to improve the life quality and meet the people economic, environmental and social needs in the present and future [23]. In addition, the European Innovation Partnership on Smart Cities and Communities has defined the smart city as the people interacts and flows the services, materials and energy using ICT strategically [24-25].

In this paper, we define the smart city as implementing the smart ICT that can integrate using the digital power in order to overcome the urbanization challenges.

2.2 Smart Cities Development and Urbanization

Literature shows that mostly all research in the smart city development is mainly focused on the rapid urbanization challenges where the urbanization impacts are on the national economic diverse and development [26]. However, the urbanization can encourage the efficiency, productivity and revolution through global connectivity. There is several sustainability issues, such as pollution and socio-economic inequality that can be happened if the urbanization control is poor [27-28].

Literature shows that there is several challenges can affect the smart cities development. Table 1 summarizes these challenges.

References No	Year	Smart Cities Development Challenges					Research Focus
		ICT Infrastructure Support	Speedy Urbanization & Lack of Wisdom From Government	Lack of Coordination & Externalities	Public & Private Partnerships	Sustainable Smart Cities Development	
[21]	2020					✓	Arguing the policymaking role for sustainable smart cities development
[22]	2020		✓				Encouraging smart cities in urbanization & emphasizing on policy development
[25]	2019				✓		The advantages of establishing innovative partnership on smart city development projects
[29]	2018		✓				Using energy infrastructure & information engagement for urbanization by smartness sectors development
[30]	2019		✓				IT design contribution for smart tourism ecosystem
[31]	2019					✓	Highlighting achieving sustainability vision for sustainable smart cities
[32]	2017	✓					The importance of big data support for the smart city development
[33]	2018	✓					The industrial revolution of data & technology as the trendsetter for urbanization
[34]	2019	✓					The basic of ICT paradigm for establishing the smart cities
[35]	2018			✓			Highlighting the rule for the industrial policy & smart city
[36]	2018			✓			Presenting the coordinated efforts towards policy development
[37]	2016				✓		Highlighting the stakeholders role as the smart cities framework
[38]	2017				✓		Demonstrating the partnership effectiveness role for building effective smart cities

3. METHODOLOGY

This study aims to investigate the key sustainable smart city development challenges and their strategical solutions. Thus, there is two research questions in this study.

- What are the key sustainable smart city development challenges?
- How these challenges can be resolved?

The interview as the qualitative research methodology is used for this purpose. The results have been analyzed and mapped to the sustainability dimensions. Furthermore, a new framework for these challenges and their respective solutions has been developed. Figure 1 shows the proposed research methodology steps that has been used in this study [39-40].

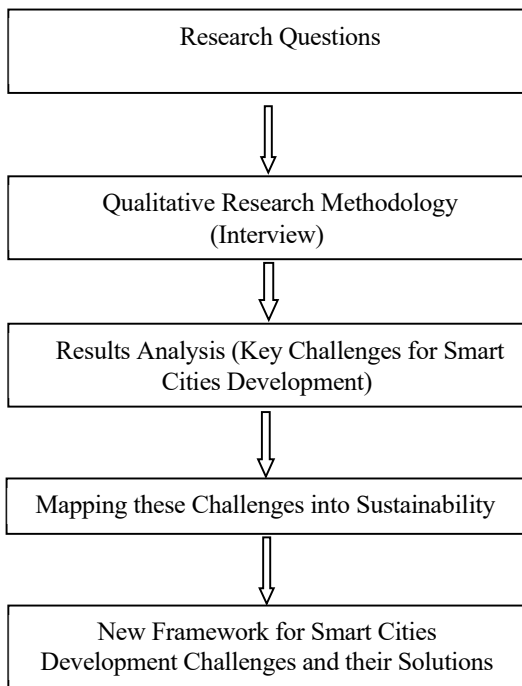


FIGURE 1. The Proposed Research Methodology Steps

3.1 Qualitative Research Methodology (Interview)

The interview as the qualitative research method is conducted in the study to collect the data and find information that was not found in literature [41]. The interview has follow several steps, (1) interview plans; (2) interview instrument generated and validated; and (3) collecting that data by running the interview. The first step is the interview plans. The stakeholders are identified, who are official from public and private sectors, information technology (IT) department, and people working on smart cities projects, in this step. There are 14 individuals selected to participate in this study. However, only 10 of them had accepted to share their views regarding the challenges that they face during their smart city

development projects. Thus, the response rate was 71% in this study. Table 2 shows the details background for participants in this study.

TABLE 2: DETAIL BACKGROUND FOR PARTICIPANTS

Management Level	Participants NO	Organization	Roles	Year of Experience
Executive Level	R1	IT	IT Manager	18
	R2	Public Sector (Government)	Executive Director	22
	R3	Private Enterprise	Project Director	16
	R4	Public Sector (Government)	Planning Consultant	26
Managerial Level	R5	Private Enterprise	Manager	8
	R6	Public Sector (Government)	Assistant Director	15
	R7	IT	Technical Assistant	9
	R8	Private Enterprise	Urban Planning	14
Operational Level	R9	Public Sector (Government)	Planning officer	8
	R10	IT	System Analyst	15

The main interview protocol is established in this study as it follows for each interview session to confirm the consistency among interviews in order to arise the results reliability. The second step is the interview instrument generated and validated. The face and content validity of the instrument has been conducted where the face validity is calculated through the Average Congruency Percentage (ACP) and the content validity is calculated through the Content Validity Index (CVI). There are four experts who have background on smart cities research and development selected for the instrument validation. Table 3 shows details background for the experts.

TABLE 3: DETAIL BACKGROUND FOR EXPERTS

Name	Roles	Year of Experience	Occupation
Expert 1	Professor	24	Academia
Expert 2	Professor	18	Academia
Expert 3	Vice President of Information System	26	Industry
Expert 4	Director	19	Industry

The experts are figured the relevancy in percentage for all questions in the ACP as shown in table 4. However, they are

C3	✓	✓	X	X	✓	✓	✓	✓	X	✓
C4	✓	✓	X	✓	✓	X	✓	✓	X	X
C5	X	✓	✓	✓	✓	✓	X	✓	✓	X
C6	✓	✓	✓	✓	X	✓	✓	✓	X	✓
C7	X	✓	✓	✓	✓	✓	✓	✓	✓	X
C8	✓	✓	✓	X	✓	✓	X	✓	X	X
C9	X	✓	✓	✓	✓	X	✓	X	✓	X
C10	X	✓	✓	✓	✓	✓	✓	X	X	X
C11	✓	✓	✓	✓	✓	✓	✓	✓	X	✓
C12	✓	✓	X	✓	X	✓	✓	X	X	X

The results indicate that the ‘Budgetary constraint’ and ‘Lack of resource’ are the highest mentioned sustainable smart cities development challenges while the ‘Lack of the smart city operational framework’ is the least shared sustainable smart cities development challenge. All of these challenges are explained below.

4.1.1 BUDGETARY CONSTRAINT

The budgetary constraint is considered as one of the sustainable smart city development challenges. The results indicate that deploying sensors, developing IS, systems integration, and creating ICT infrastructure [42] for the cities are required sufficient budgets allocation. In addition, according to the executive management level participants, the technical support and facilities are tagged with the release of sufficient budgets for installing them, maintenance and up-gradation of the existing infrastructure.

4.1.2 LACK OF RESOURCES

According to the managerial level participants, the lack of resources is considered as one of the sustainable smart cities development challenge. They draw attention to several resources types, such as equipment, technology, sensors, finance and human. They mentioned that almost all of the public and private works are interconnected and thus any lack of resources may halt the overall sustainable smart cities development.

4.1.3 LACK OF INSTITUTIONAL CAPACITY TO DELIVER TECHNOLOGY

According to the IT and private enterprise participants, the lack of institutional capacity for the delivering technology that required for the sustainable smart cities development can be considered as one of the sustainable smart cities development challenge. They have listed several skills and experience for the institutions that involved in the sustainable smart city development, such as the organizations capacity and expertise knowledge. For example, the people who work in the public and private sectors may require to build the capacity to deliver the sustainable smart cities development technologies, such as 5G communication network, IoT and the AI expert systems [43-48].

4.1.3 LACK OF SYSTEM INTEGRATION

According to the private enterprises participants, the systems development of the smart education, healthcare, parking, and others services are somewhat in progress and under development. However, these development cannot accomplish the sustainable smart cities development purpose. Thus, the lack of systems integration is considered as the key challenge of sustainable smart city development [49]. Furthermore, the integration of these systems can support for communication and sharing data in order to provide of the services to the residents.

4.1.4 SOCIAL ACCEPTABILITY

According to the participants who work on public sector of executive and managerial levels, the social acceptability that based on the services satisfaction of the smart cities can be considered as another the sustainable smart cities development challenges. Moreover, the results indicate that the residents quality of life, smart cities efforts and their services have to be improved and meet the social needs. However, the level of residents awareness about smart cities services can increase the social acceptance of the smart cities. For instance, the residents awareness about the smart education, smart healthcare, and other smart services can improve the social life [50-51].

4.1.5 LACK OF AWARENESS LEVEL IN THE SMART CITY DEVELOPMENT AMONG RESIDENTS

The participants consider the lack of awareness level in the smart city development among residents as another challenge for sustainable smart cities development. Hence, the participants are advised to arrange such awareness program among the residents regarding the sustainable smart cities development. In addition, one of the participant said that scheduling the training sessions for residents about the sustainable smart cities services practice can help for overcome this challenge. Consequently, the educational institutes, universities and ministries who are in charge can use their platform to provide these training sessions and awareness programs throughout the seminars, public talks and social media materials [52].

4.1.6 THE NEED TO DRIVE TOWARDS CONTENT DEVELOPMENT

According the participants response, the sustainable smart cities development is equally based on the computing, infrastructure, and the right contents in IS. They highlighted that the organizations especially the large enterprises have to deal with the digital technologies and IS in order to create the data centers for the content development. They considered that the lack of efficient and complete digital contents can be another challenge of the sustainable smart cities development.

As a results, the enterprise have to develop and schedule IS enhancement throughout their vision and policy.

4.1.7 LACK OF STRATEGIC APPROACH FOR THE SMART CITIES TRANSFORMATION

According to the participants who work on public sector of executive level, the lack of strategic approach for the smart cities transformation can be considered as another challenge of the sustainable smart cities development. They highlighted that the development of smart cities required to have great infrastructure for communication and networks and clear strategic plans. This strategic plan is the roadmap for the sustainable smart cities development. One of the participants mentioned that these strategic plans have to be divided into processes and subprocesses to be followed [53].

4.1.8 DISAGREEMENT ON STANDARDIZING THE SMART CITY MODEL

According the participants from the managerial and executive levels, getting the stakeholders consensus on the unified sustainable smart cities model can be considered as another challenge where the stakeholders can involve in several issues that related to developing the smart cities, such as the governance, technological, political and social. Furthermore, one of the participant who works on enterprise private is identified that the lack of consensus can be issued by the governance policy and technology transfer. Hence, because of the timely technology transfer in order to build the standardized model, the standardized sustainable smart cities model challenge can be become more critical.

4.1.9 LACK OF OVERREACHING INSTITUTION TO CREATE THE GOVERNANCE STRUCTURE

The lake of overreaching institution to create the governance structure can be considered as another challenge of the sustainable smart cities development. The participants highlighted that the governing body have to overreach its responsibilities and controls for setting up the sustainable smart cities development. The complete governance structure that can rightly communicate between different stakeholders, such as government, private enterprise, telecommunications authorities and infrastructure builders are required to solve this challenge.

4.1.10 LACK OF SUSTAINABLE FOCUSED STRATEGIES

The participants highlighted that there is a lack of focus on all sustainable dimensions: economic, social, technological and environmental dimensions for the development of sustainable smart cities. They are considered that the lack of sustainable focused strategies is another challenge of the

sustainable smart cities development. They asked the countries to save their resources and focus on the issues of sustainability in order to meet their needs. Consequently, the plans of the smart cities development have to address the economic, social, technological and environmental sustainability dimensions on their sustainable focused strategies.

4.1.11 LACK OF THE SMART CITIES OPERATIONAL FRAMEWORK

The working paradigm of the infrastructure communication, the data centers operations, the enterprise communication and the systems integration are an example of the smart cities operational framework. According to the participants, the lack of the operational framework can be considered as one of the sustainable smart cities development challenge. They highlighted that the public and private sectors awareness about the operational framework of the sustainable smart cities development is not sufficient. As a results, it is an important to create the smart cities operational framework that can be used as the guideline for developing and deploying the sustainable smart cities.

4.2 Mapping the Sustainable Smart Cities Development Challenges to Sustainability Dimensions

The sustainable smart cities development challenges can affect the governance, skills and resources. However, literature shows that these challenges are not mapped into the sustainability dimensions. Thus, the 12 smart cities development challenges are mapped into the four sustainability dimensions: economic, social, technological and environmental dimensions in this paper as shown in figure 2.

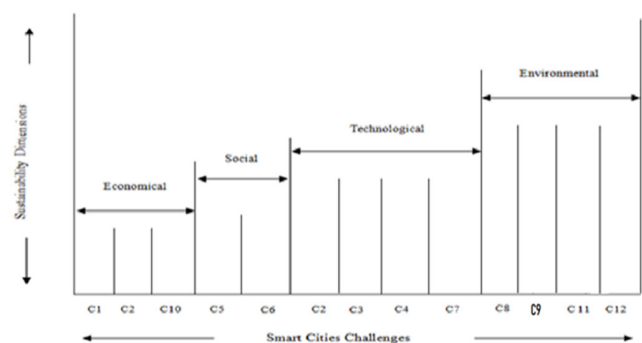


Figure 2: Mapping the Sustainable Smart Cities Development Challenges into Sustainability Dominations

Firstly, the results indicate that there are three challenges of the sustainable smart cities development related to the economic dimension. These challenges are the budgetary constraint (C1), the lack of resources (C2), and the lack of the

overarching institution to create the governance structure (C10) and they are mapped into the economic dimension of the sustainability.

Secondly, the results indicate that there are two challenges of the sustainable smart cities development related to the social dimension. These challenges are the social acceptability (C5) and the lack of awareness level in the smart city development among residents (C6) and they are mapped into the social dimension of the sustainability.

Thirdly, the results indicate that there are four challenges of the sustainable smart cities development related to the technological dimension. These challenges are the lack of resources (C2), the lack of institutional capacity to deliver technology (C3), the lack of systems integration (C4) and the need to drive towards content development (C7) and they are mapped into the technological dimension of the sustainability.

Lastly, the results indicate that there are three challenges of the sustainable smart cities development related to the environmental dimension. These challenges are the lack of strategically approach in the smart city transformation (C8), the lack of sustainable focused strategies (C11), and the lack of the smart city operational framework (C12) and they are mapped into the environmental dimension of the sustainability.

5. SUSTAINABLE SMART CITIES DEVELOPMENT CHALLENGES AND SOLUTIONS FRAMEWORK

In this paper, there are several solutions that can be used to overcome the sustainable smart cities development challenges and they are grouped in framework as shown in figure 3. These solutions have been collected from the participants via their interviews and authors experience.

The results indicate that all of 10 participants have considered the budget constraint as one of the key challenges of sustainable smart cities development. Most of them asked the countries to consider all available funding sources in order to deal with budget challenge. In addition, they mentioned that using the multi-year payment plan for their smart cities projects can support the countries for overcome the budget constraint challenge.

The results indicate that all of 10 participants have considered the lack of resources as one of the key challenges of sustainable smart cities development. Most of them have suggested the procedures of hiring people and developing their smart cities development skills in order to overcome this challenge. Moreover, generating the flexible policy and the reducing the technologies and equipment tax can be considered as others solutions for overcoming the lack of resources challenge. Two of the participants are advised to

have the comprehensive policy for technology transfer to overcome this challenge.

The results indicate that 70% of the participants are considered the lack of institutional capacity to deliver technology as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants are asked the countries to send the people who work in smart cities development projects to the developed countries to improve their skills, share and transfer knowledge. Furthermore, the practical training sessions about the recent technologies and the professional skills for the sustainable smart cities development can be consider as another solution to overcome this challenge.

The results indicate that 60% of the participants are considered the lack of systems integration as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants were suggested to flow the software engineering development process. For example, they suggested to follow the process of planning, designing, developing, implementing and testing the sustainable smart cities development projects. As results, the effective technical reviews and the most correct designing have to be applied during all the system integration.

The results indicate that 70% of the participants are considered the social acceptability as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, most of the participants asked the countries to improve their residents awareness regarding the sustainable smart cities development throughout the training sessions and seminars. Furthermore, some of them were encouraged the countries to have their residents who have any interest in the sustainable smart cities development to work as the volunteers [54].

The results indicate that 80% of the participants are considered the lack of awareness level in the smart city development among residents as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, most of the participants were asked the countries to use their media channels for broadcasting the awareness programs regarding the sustainable smart cities development. They were suggested to increase the residents awareness through sharing the sustainable smart cities benefits in public.

The results indicate that 80% of the participants are considered the need to drive towards content development as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants mentioned that the residents have to be aware about the advantages of having the useful, accurate and relevant content. They advised the developers to aware about the content timeliness advantages and then regularly update the content.

The results indicate that 60% of the participants are considered the lack of strategically approach in the smart city transformation as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants were suggested to understand the purpose and the vision of the sustainable smart cities

development. Furthermore, one of the participant mentioned the envision with the objective of the smart cities development including the financial goals, operational methods and customer relation [55].

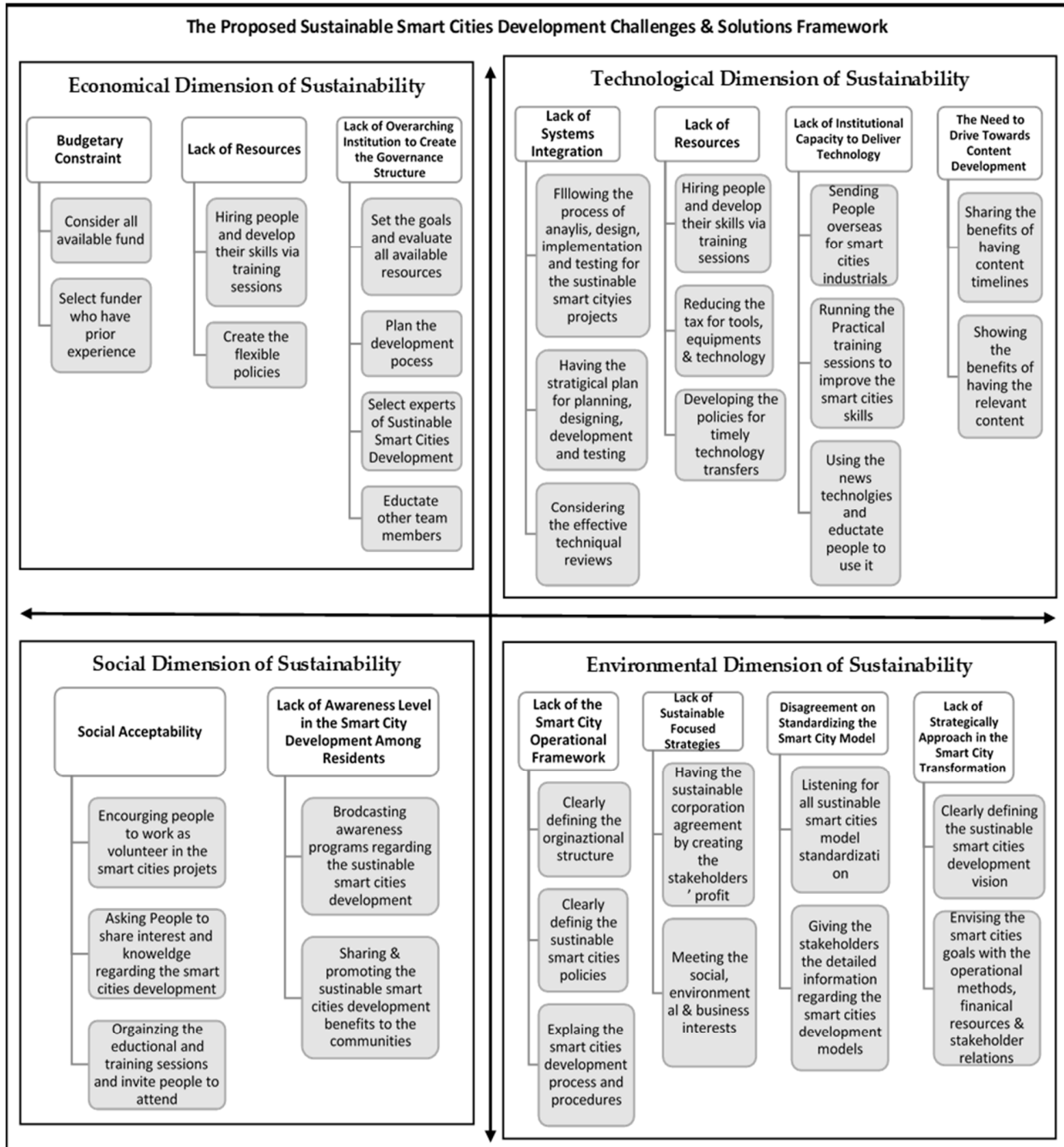


Figure 3: Framework of the Sustainable Smart Cities Development Challenges and Solutions

The results indicate that 60% of the participants are considered the disagreement on standardizing the smart city model as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants were suggested to listen to all of the sustainable smart cities development stakeholders. They asked all of the sustainable smart cities stakeholders to have more detail information regarding the sustainable smart cities model and thus they can have the proactive listening in order to eliminate the disagreement about the sustainable smart cities development model standardization.

The results indicate that 60% of the participants are considered the lack of overarching institution to create the governance structure as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants were suggested to set the global goals, plan the complete processes and evaluate all of the available resources. In addition, they asked the countries to select the expert who can understand the sustainable smart cities development and can lead the governance. Furthermore, other team members have to be educated in order to improve their awareness regarding the governance models.

The results indicate that 90% of the participants are considered the lack of sustainable focused strategies as one of the key challenges of sustainable smart cities development. In order to overcome this challenge, most of the participants were suggested that the organizations should have the agreement regarding the sustainable corporation by creating the stakeholders' profit within the environment protection. In addition, they mentioned that the social, environmental and business interests have to be met in order to solve this challenge.

Lastly, the results indicate that 50% of the participants are considered the lack of the smart city operational framework as lowest frequency challenges of sustainable smart cities development. In order to overcome this challenge, some of the participants were suggested to have the great organization structure and clear management of the operational framework. Moreover, clearly defining and outlining the sustainable smart cities development policies can be considered as another solution for overcome this challenge.

6. CONCLUSIONS

This study aims to presents the overview of research in the smart cities sustainability and development domain. It aims to investigate the key challenges of the sustainable smart cities development that faced by the developers from the public and private sectors. The interview as the qualitative research method is conducted in the study to collect the data. There

were 10 experts on the sustainable smart cities development project interviewed in this study. The results indicate that there are 12 sustainable smart cities development challenges named: (1) budgetary constraint; (2) lack of resources; (3) lack of institutional capacity to deliver technology; (4) lack of systems integration; (5) social acceptability; (6) lack of awareness level in the smart city development among residents; (7) the need to drive towards content development; (8) lack of strategically approach in the smart city transformation; (9) disagreement on standardizing the smart city model; (10) lack of overarching institution to create the governance structure; (11) lack of sustainable focused strategies; and (12) lack of the smart city operational framework. Furthermore, the solutions framework for these challenges was proposed as the guidelines to overcome or minimize them.

However, this study has several limitations. For example, the interviewers ability may affect the quality of the collected data. Only a single method has been used in this study. In addition, the sample size is one of the limitations of this study. Therefore, conducting the questionnaire to collect data for the sustainable smart cities development challenges and solutions in order to measure the quality of interview results can be considered as the future research.

REFERENCES

- [1] Olawumi, T. O., & Chan, D. W. (2019). Critical success factors for implementing building information modeling and sustainability practices in construction projects: A Delphi survey. *Sustainable Development*, 27(4), 587-602.
- [2] Anisurrahman, M., & Alshuwaikhat, H. M. (2019). Determining sustainability assessment indicators for the Holy city of Makkah, Saudi Arabia. *Arabian Journal for Science and Engineering*, 44(5), 5165-5178.
- [3] Khan, H. H., Malik, M. N., Zafar, R., Goni, F. A., Chofreh, A. G., Klemeš, J. J., & Alotaibi, Y. (2020). Challenges for sustainable smart city development: A conceptual framework. *Sustainable Development*, 28(5), 1507-1518.
- [4] Simpson, N. P., Simpson, K. J., Shearing, C. D., & Cirolia, L. R. (2019). Municipal finance and resilience lessons for urban infrastructure management: a case study from the Cape Town drought. *International Journal of Urban Sustainable Development*, 11(3), 257-276.
- [5] Sun, H., Mohsin, M., Alharthi, M., & Abbas, Q. (2020). Measuring environmental sustainability performance of South Asia. *Journal of Cleaner Production*, 251, 119519.
- [6] Malik, M. N., Khan, H. H., Chofreh, A. G., Goni, F. A., Klemeš, J. J., & Alotaibi, Y. (2019). Investigating students' sustainability awareness and the curriculum of technology education in Pakistan. *Sustainability*, 11(9), 2651.
- [7] Alotaibi, Y. (2020, March). Automated Business Process Modelling for Analyzing Sustainable System Requirements Engineering. In 2020 6th International Conference on Information Management (ICIM) (pp. 157-161). IEEE.

- [8] Pourreza, P., Saberli, M., Azadeh, A., Chang, E., & Hussain, O. (2018). Health, safety, environment and ergonomic improvement in energy sector using an integrated fuzzy cognitive map–Bayesian network model. *International Journal of Fuzzy Systems*, 20(4), 1346-1356.
- [9] Al-asmari, A. M., Aloufi, R. I. & Alotaibi, Y. (2021). B A Review of Concepts, Advantages and Pitfalls of Healthcare Applications in Blockchain Technology. *IJCSNS International Journal of Computer Science and Network Security*, 21 (5): 199-210.
- [10] Suryanarayana, G., Chandran, K., Khalaf, O. I., Alotaibi, Y., Alsufyani, A., & Alghamdi, S. A. (2021). Accurate Magnetic Resonance Image Super-Resolution Using Deep Networks and Gaussian Filtering in the Stationary Wavelet Domain. *IEEE Access*, 9, 71406-71417.
- [11] Alotaibi, Y., Malik, M. N., Khan, H. H., Batool, A., ul Islam, Saif, Alsufyani, A., & Alghamdi, S. (2021). Suggestion Mining from Opinionated Text of Big Social Media Data. *CMC-COMPUTERS MATERIALS & CONTINUA*, 68(3), 3323-3338.
- [12] Peng, X., & Smarandache, F. (2019). Novel neutrosophic Dombi Bonferroni mean operators with mobile cloud computing industry evaluation. *Expert Systems*, 36(4), e12411.
- [13] Silva, B. N., Khan, M., & Han, K. (2017). Integration of Big Data analytics embedded smart city architecture with RESTful web of things for efficient service provision and energy management. *Future generation computer systems*.
- [14] Silva, B. N., Khan, M., Jung, C., Seo, J., Muhammad, D., Han, J., ... & Han, K. (2018). Urban planning and smart city decision management empowered by real-time data processing using big data analytics. *Sensors*, 18(9), 2994.
- [15] Bates, O., & Friday, A. (2017). Beyond data in the smart city: repurposing existing campus IoT. *IEEE Pervasive Computing*, 16(2), 54-60.
- [16] Alotaibi, Y. (2020). A New Secured E-Government Efficiency Model for Sustainable Services Provision. *Journal of Information Security and Cybercrimes Research*, 3(1), 75-96.
- [17] Li, G., Liu, F., Sharma, A., Khalaf, O. I., Alotaibi, Y., Alsufyani, A., & Alghamdi, S. (2021). Research on the natural language recognition method based on cluster analysis using neural network. *Mathematical Problems in Engineering*, 2021.
- [18] Qian, Y., Wu, D., Bao, W., & Lorenz, P. (2019). The internet of things for smart cities: Technologies and applications. *IEEE Network*, 33(2), 4-5.
- [19] Almusaylim, Z. A., & Zaman, N. (2019). A review on smart home present state and challenges: linked to context-awareness internet of things (IoT). *Wireless Networks*, 25(6), 3193-3204.
- [20] Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research—An information systems perspective. *International Journal of Information Management*, 47, 88-100.
- [21] Lytras, M. D., & Şerban, A. C. (2020). E-government insights to Smart Cities Research: European Union (EU) study and the Role of Regulations. *IEEE Access*, 8, 65313-65326.
- [22] Tan, S. Y., & Taeihagh, A. (2020). Smart City Governance in Developing Countries: A Systematic Literature Review. *Sustainability*, 12(3), 899.
- [23] Lytras, M. D., & Visvizi, A. (2018). Who uses smart city services and what to make of it: Toward interdisciplinary smart cities research. *Sustainability*, 10(6), 1998.
- [24] Rana, N. P., Luthra, S., Mangla, S. K., Islam, R., Roderick, S., & Dwivedi, Y. K. (2019). Barriers to the development of smart cities in Indian context. *Information Systems Frontiers*, 21(3), 503-525.
- [25] Mora, L., Deakin, M., Reid, A., & Angelidou, M. (2019). How to overcome the dichotomous nature of smart city research: proposed methodology and results of a pilot study. *Journal of Urban Technology*, 26(2), 89-128.
- [26] Calzada, I. (2018). (Smart) citizens from data providers to decision-makers? The case study of Barcelona. *Sustainability*, 10(9), 3252.
- [27] Ameen, R. F. M., & Mourshed, M. (2019). Urban sustainability assessment framework development: The ranking and weighting of sustainability indicators using analytic hierarchy process. *Sustainable Cities and Society*, 44, 356-366.
- [28] Mikulčić, H., Wang, X., Duić, N., & Dewil, R. (2020). Environmental problems arising from the sustainable development of energy, water and environment system. *Journal of Environmental Management*, 259, 109666.
- [29] Nyberg, R. A. (2018). Using ‘smartness’ to reorganise sectors: Energy infrastructure and information engagement. *International Journal of Information Management*, 39, 60-68.
- [30] Arenas, A. E., Goh, J. M., & Urueña, A. (2019). How does IT affect design centrality approaches: Evidence from Spain’s smart tourism ecosystem. *International Journal of Information Management*, 45, 149-162.
- [31] Caird, S. P., & Hallett, S. H. (2019). Towards evaluation design for smart city development. *Journal of urban Design*, 24(2), 188-209.
- [32] Zhu, C., Zhou, H., Leung, V. C., Wang, K., Zhang, Y., & Yang, L. T. (2017). Toward big data in green city. *IEEE Communications Magazine*, 55(11), 14-18.
- [33] Iammarino, S., McCann, P., & Ortega-Argilés, R. (2018). International business, cities and competitiveness: recent trends and future challenges. *Competitiveness Review: An International Business Journal*.
- [34] Kummitha, R. K. R., & Crutzen, N. (2019). Smart cities and the citizen-driven internet of things: A qualitative inquiry into an emerging smart city. *Technological Forecasting and Social Change*, 140, 44-53.
- [35] Vu, K., & Hartley, K. (2018). Promoting smart cities in developing countries: Policy insights from Vietnam. *Telecommunications Policy*, 42(10), 845-859.
- [36] Bhardwaj, M., Naosekpan, A. S., & Tewari, R. (2018). Comparative study of Asian economies: Lessons for India. *Journal of Science and Technology Policy Management*.
- [37] Khatoun, R., & Zeadally, S. (2016). Smart cities: concepts, architectures, research opportunities. *Communications of the ACM*, 59(8), 46-57.
- [38] Bacco, M., Delmastro, F., Ferro, E., & Gotta, A. (2017). Environmental monitoring for smart cities. *IEEE Sensors Journal*, 17(23), 7767-7774.
- [39] Alotaibi, Y. (2016). Business process modelling challenges and solutions: a literature review. *Journal of Intelligent Manufacturing*, 27 (4): 701-723.

- [40] Alotaibi, Y & ,Liu, F. (2017). Survey of Business Process Management: Challenges and Solutions. *Enterprise Information Systems*, 11 (8), 1119-1153.
- [41] Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods*. SAGE Publications Limited.
- [42] Aleksic, S., & Mujan, V. (2018). Exergy cost of information and communication equipment for smart metering and smart grids. *Sustainable Energy, Grids and Networks*, 14, 1-11.
- [43] Cui, L., Xie, G., Qu, Y., Gao, L., & Yang, Y. (2018). Security and privacy in smart cities: Challenges and opportunities. *IEEE access*, 6, 46134-46145.
- [44] Sanchez-Hidalgo, M. A., & Cano, M. D. (2018). A survey on visual data representation for smart grids control and monitoring. *Sustainable Energy, Grids and Networks*, 16, 351-369.
- [45] Khalkhali, H., & Hosseinian, S. H. (2020). Multi-class EV charging and performance-based regulation service in a residential smart parking lot. *Sustainable Energy, Grids and Networks*, 100354.
- [46] Ali, T., Irfan, M., Alwadie, A. S., & Glowacz, A. IoT-Based Smart Waste Bin Monitoring and Municipal Solid Waste Management System for Smart Cities.
- [47] Alotaibi, Y., & Liu, F. (2014). A novel secure business process modeling approach and its impact on business performance. *Information Sciences*, 277, 375-395.
- [48] Khalaf, O. I., Sokiyna, M., Alotaibi, Y., Alsufyani, A., & Alghamdi, S. (2021). Web Attack Detection Using the Input Validation Method: DPDA Theory. *CMC-COMPUTERS MATERIALS & CONTINUA*, 68(3), 3167-3184.
- [49] Javidroozi, V., Shah, H., & Feldman, G. (2019). Urban Computing and Smart Cities: Towards Changing City Processes by Applying Enterprise Systems Integration Practices. *IEEE Access*, 7, 108023-108034.
- [50] Gonzalez, E. L., Chinelli, C. K., Azevedo Guedes, A. L., Vazquez, E. G., Hammad, A. W., Haddad, A. N., & Pereira Soares, C. A. (2020). Smart and Sustainable Cities: The Main Guidelines of City Statute for Increasing the Intelligence of Brazilian Cities. *Sustainability*, 12(3), 1025.
- [51] Rădulescu, C. M., Slava, S., Rădulescu, A. T., Toader, R., Toader, D. C., & Boca, G. D. (2020). A Pattern of Collaborative Networking for Enhancing Sustainability of Smart Cities. *Sustainability*, 12(3), 1042.
- [52] Lin, C., Zhao, G., Yu, C., & Wu, Y. J. (2019). Smart city development and residents' well-being. *Sustainability*, 11(3), 676.
- [53] D'Auria, A., Tregua, M., & Vallejo-Martos, M. C. (2018). Modern conceptions of cities as smart and sustainable and their commonalities. *Sustainability*, 10(8), 2642.
- [54] Alkhamash, E. H., Jussila, J., Lytras, M. D., & Visvizi, A. (2019). Annotation of smart cities Twitter micro-contents for enhanced citizen's engagement. *IEEE Access*, 7, 116267-116276.
- [55] Kuru, K., & Ansell, D. (2020). TCitySmartF: A comprehensive systematic framework for transforming cities into smart cities. *IEEE Access*, 8, 18615-18644.