PUTRAJAYA SMART CITY: A JOURNEY TRACES BACK TO ITS PAST, NOW AND NEAR FUTURE

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Abstract

This is the first study conducted on Putrajaya, Malaysian federal government administrative capital city, examining its ongoing second-generation smart city development which has not been conducted previously. A case study approach is used to explore the specific context of the leading role model of Malaysian smart city progress. The objectives of this study are: i) to assess the progress of Putrajaya smart city development; ii) to compare how Putrajaya fares against recommended smart city approaches; and iii) what best practices that we can learn from Putrajaya's smart city development. The initiatives list extracted from the Putrajaya Smart City Blueprint was used as the basis and triangulated with interviews with Putrajaya local authority and town & country planners. In addition, network analysis to study multi-helix collaboration was performed using open-source software Gephi. This study found that Putrajaya smart city development progress is as per expectation in terms of initiatives execution, fares fairly well in balanced development across domains and integration of bottom-up approach in its traditional top-down administration but lagging behind in holistic strategy and multi-stakeholders collaboration. It exhibits self-sufficiency and cohesiveness of smart city initiatives which serves as the cornerstones of best practices that other cities can potentially learn from.

Keywords: smart city; Putrajaya; best practices; systems theory; operations management

1. INTRODUCTION

In 1993-95, the development of Putrajaya started as a federal capital of the country (John 2004; Omar, 2004; Moser, 2010) though at that point, the term smart city was not used. In this study, this phase is referred to as the first-generation of smart city development in Malaysia where it formed the then grandeur scheme of Multimedia Super Corridor development. Fast forward to 2018, the second-generation development of

smart city in Malaysia was specifically launched through Malaysia Smart City Framework (Malaysian Ministry of Housing and Local Government, 2018) and Putrajaya Smart City Blueprint (Perbadanan Putrajaya, 2020).

The objectives of this study are: i) to assess the progress of smart city development in Putrajaya; ii) to compare how Putrajaya's approach fare against recommended smart city approaches; and iii) what best practices that we can learn from Putrajaya's smart city development. The theoretical perspective in this study is drawn upon the literature of smart city, operations management and systems theory. Analysis of activities data during the conceptualization of Putrajaya smart city blueprint; operationalized initiatives; and work in progress and future initiatives, is used to examine the research questions.

This paper starts with literature review on systems theory, smart city from operations management view, smart city concepts, characteristics and best practices followed by smart city development background in Malaysia, particularly, Putrajaya. Next, research methodology is elaborated in Section 3. Subsequent Section 4 elaborates the analysis and findings of smart city initiatives in Putrajaya while Section 5 presents the discussion and recommendations. The paper concludes with summary and limitation remarks in Section 6.

2. LITERATURE REVIEW

2.1. Smart City from the Perspective of Systems Theory

System is defined as "sets of elements standing in interaction" (Von Bertalanffy, 1968). In the context of smart city, elements consist of i) smart city stakeholders such as the government, businesses, citizens, ii) infrastructure such as hardware, software and network which are connected and integrated and iii) available resources including natural resources, human capital, etc. Smart city structure can be viewed as sets of relations that exists among its stakeholders and infrastructure, which has a diverse combination of elements and directionalities. Smart city can be conceptualized as systems (physical and non-physical) that form a comprehensive cosmopolitan of system. Examples include physical systems such as network, energy, water, building, environment, transportation and non-physical system such as education, governance, economy, public health, etc. Smart city is an open system where many interdependencies and exchanges between physical and non-physical systems to operate a city 24x7 efficiently under various conditions.

2.2. Smart City from the Perspective of Operations Management

Efficiency, transparency and involvement are the three areas of interest from the viewpoint of operations management (Mak, 2020). They are conceptualized as the connections between technology, data and operations by Mak (2020). Firstly, in a smart city, efficiency of physical and economic aspects is equally important. As summarized by Van Mieghem (2012), classic and original operations management focus on "what is the best way" question (physical) while operations economics and empirical operations management focus on "what happens and why" question (economic). Volume and speed of data which enable

optimization of various processes creates unprecedented physical efficiency in urban life, while management and alignment of incentives among stakeholders to maximize system-wide performance, generates economic efficiency. Secondly, transparency enabled through accessible (especially open) data empowers the citizens and ensures government accountability. Thirdly, integrated and connected technology enables bottom-up involvement of users in the planning and delivery of services in smart city contributing to value creation.

2.3. Global Smart City Development

The evolving nature in urban (smart) city depicts the wicked problem elaborated by Head and Alford (2015) such as seen in pilot versus scaling up phase; different collaborative dynamics involving national, state, local and international actors; and diverse roles played by each actor (government, various organizations, citizens) to achieve public value creation. This complex problem calls for more dynamic and diverse collaborative approach (Thabit & Mora, 2023). Borrás and Edler (2020) highlight those mixed roles assumed by the state (i.e. government and public policy) naturally adds up to the complexity of socio-technical system transformation governance seen in smart cities. They posit that the state can act as a facilitator, promoter, lead user, enabler of societal engagement, initiator and gatekeeper, depending on the needs of the situation and contexts. Moreover, local government is seen as adding more value to the smart cities scene by being a steward rather than bureaucrat (Thabit & Mora, 2023).

There are numerous conceptualizations of smart cities in its evolution in terms of characteristics as well as implementation. According to Angelidou (2014), "Smart cities are all urban settlements that make a conscious effort to capitalize on the new Information and Communications Technology (ICT) landscape in a strategic way, seeking to achieve prosperity, effectiveness and competitiveness on multiple socio-economic levels". Another highly cited definition is by Caragliu et al. (2011) which defines a city "to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance". Both definitions share essence of what a smart city is (capitalization and investment in technology and human-social aspects), its intended outcome (prosperity, effectiveness, competitiveness, high quality of living) and the means of achieving what it intends to be (ICT, resources management and participatory governance). Despite discrepancies of what consists of smart city development that were widely present in earlier literatures (e.g. Caragliu et al. 2011; Angelidou, 2014; Yigitcanlar et al., 2019; Mora et al., 2019; Praharaj & Han, 2019), smart city concept is accepted as an evolution over time rather than an end state. Smart city is framed as "fluid status of becoming rather than being" (Kamalipour & Peimani, 2015) where the "smart city is more of a strategy than a reality, a strategic vision for the future" (Angelidou et al., 2018).

In general, smart cities share common traits of connectedness, openness and service innovation (Lee et al., 2014) with the same ultimate goal of creating a more livable city for its citizens. The notion of creating a city that's benefiting all as the common goal is

underlined by UN Habitat's flagship program People-Centered Smart Cities in advocating digital innovation and digital transformation to promote development, sustainability, prosperity and inclusivity (UN Habitat, 2022a, 2022b). Mora et al. (2019) analyze four leading European cities in smart city development, from which lessons learnt from these cities are best practices to be considered in smart city design and implementation. The best practices put forward are: i) Using strategy grounded on holistic vision rather than being technology led; ii) Move towards quadruple helix collaboration involving public-private-research-citizen/NGO relationship; iii) Using a combined top-down and bottom-up approach, optimizing the benefit of government led and community driven effort; and iv) Adopting a cross-domains approach addressing different areas.

Contextual factors such as degree of autonomy and local conditions are highlighted by Ruhlandt (2018) on smart city governance. The notion of no one-size fits all on smart city development points to place-based strategies emphasizing on existing economies, context specific, collaborative angled and transition nature, moving away from the obscure generic strategy (e.g. Lee et al., 2014; Letaifa, 2015; Pereira et al., 2017;

Lim et al., 2019; Mora et al., 2019, 2023; Jiang et al., 2020; Csukás & Szabó, 2021; Esposito et al., 2021; Brazeau-Béliveau & Cloutier, 2021; Thabit & Mora, 2023).

2.4. Smart City Development in Malaysia

The second-generation of smart city primarily Putrajaya alongside several others is driven by the global agenda of smart city whereby the Government of Malaysia initiated the nationwide smart city framework - Malaysia Smart City Framework (MSCF) with target roadmap of Phase 1 (Foundation Stage) from 2019 to 2020, Phase 2 (Development Stage) from 2021 to 2022 and Phase 3 (Advanced Development and Monitoring Stage) from 2023 to 2025.

Putrajaya Smart City Blueprint was approved on 29th January 2019, channeled through 4 urban dimensions (Figure 1) which propagate into 7 smart city domains (Figure 2) aligned with the 7 smart domains in MSCF despite slight differences in nomenclatures. This blueprint is a governance instrument which contains narratives of "articulation and communication of future smart city visions" (Borrás and Edler, 2020).
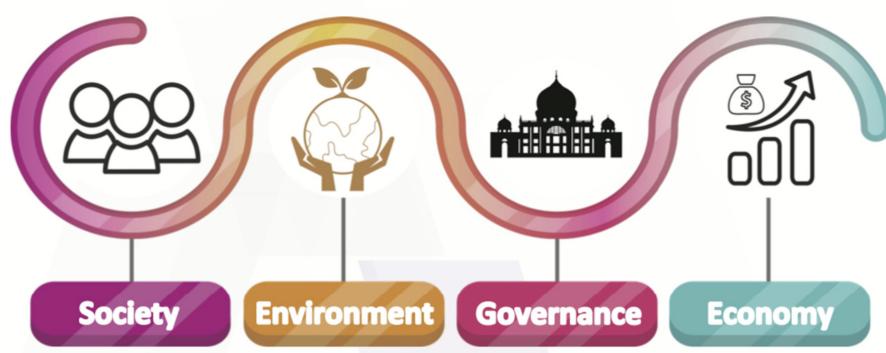

Figure 1. The Four Urban Dimensions (Extracted from Putrajaya Smart City Blueprint)

Figure 2. The Seven Smart City Domains (Extracted from Putrajaya Smart City Blueprint)

The blueprint was created with Putrajaya smart city playing a significant role in supporting provision of communication technologies as a basic service agenda in UN Habitat New Urban Agenda; nurturing smart communities as per 11th and 12th Malaysia Plan; development of broadband technology to achieve 100% coverage in the Peninsular of Malaysia as indicated in National Physical Plan 3; transforming into global digital smart city aligning to National Urbanization Plan; and elevating Putrajaya from an administrative dominant function to a well-balanced socio-economic smart city as per Putrajaya Structure Plan 2025 (Perbadanan Putrajaya, 2014).

The origin of Putrajaya dated back to June 1993 where Perang Besar in Sepang, Selangor was designated as the site to build Malaysia's new federal government administrative center but without explicit intention of conceptualizing a smart city as such notion had not existed then. As of 2022, Putrajaya is divided into 20 precincts with a population of 120,000 (Department of Statistics Malaysia, 2023). Perbadanan Putrajaya (Putrajaya Corporation), acts as a local council, established in March 1996 under Perbadanan Putrajaya Act 1995 (Act 536) to administer and manage the Federal Territory of Putrajaya where Putrajaya was declared as a new Federal Territory on 1 February 2001 (Perbadanan Putrajaya, 2021a).

Tracing the journey of smart city development in Putrajaya, this paper thus attempts to explore and understand the intricacies of its origin, interrelated activities, policies and stakeholders in the development of Putrajaya smart city through the lens of systems theory, operations management and existing smart city literature.

3. RESEARCH METHODOLOGY

3.1. Research design

Our preliminary study on the progress of smart city implementation in Malaysia conducted with PLANMalaysia pointed to an overall early stage of smart city implementation. The agency measures smart city maturity by categorizing cities into 5 stages (in increasing order of maturity) which are pre-smart city, early adopter, developing, leading and visionary. Most of the Malaysian cities are in the pre-smart city and early adopter stage of smart city

implementation. Cities that are in the pre-smart city stage do not have a completed and approved smart city action plan while smart cities in the early adopter stage are at the beginning of smart city journey with a completed development of smart city action plan with minimal initiatives in place. Putrajaya is in the developing stage where there is tangible progress observed in terms of execution of smart city blueprint action plan since 2018. Based on the rationale that Putrajaya is the only leading smart city in Malaysia, it is selected as the site for study of smart city progress and best practices comparison. A case study approach is used as it is well suited to explore the specific context (Flyvbjerg, 2001), in this case the Putrajaya smart city development.

3.2. Data collection

The fieldwork of this study was carried out in the first quarter of 2023. The list of initiatives extracted from the Putrajaya Smart City Blueprint was used as the basis of this study and subsequently, triangulated with information from 2 sessions of onsite interview with 3 officers from the local authority, Perbadanan Putrajaya and 2 officers from the federal agency PLANMalaysia. The first interview is a 2.5-hour semi structured interview with Perbadanan Putrajaya focusing on progress of smart city initiatives. The second interview is a 2-hour interview with PLANMalaysia, focuses on the federal agency role pertaining to Putrajaya smart city development and nationwide smart city standards and measurements.

Additional initiatives that are not found in the blueprint, gathered from the interviews are added to the final list of initiatives for analysis. To further strengthen data triangulation, secondary data source including data obtained from official government documents and online news article and information found on non-government official webpages are used to supplement the information of status and stakeholders involved for the searched initiatives.

3.3. Data Preparation and Tools

After data collection, the list of smart city initiatives is consolidated in an Excel spreadsheet version 16.74 for further data preparation task. This task entails mapping 4 pieces of information to each initiative, namely implementation status, whether it is data centric, initiative type and stakeholders involved. Each initiative is reviewed against collected primary and secondary data to complete the mapping, and subsequently mapped information for each initiative is coded. For coding, firstly, implementation status for each initiative is coded as the following: i) Operational or In Progress; ii) Upcoming (Table 1). Secondly, based on an initiative's desired outcome and the extent data is used to operate services related to the initiative, an initiative is coded as i) Yes or ii) No, in relation to being data centric. The next two codes on type of initiatives and type of stakeholders are adapted from the method used by Mora et al. (2019) in investigating technology led initiatives and multi-helix collaboration, respectively. Type of initiative is coded as one of the following: i) Services & Applications; ii) Community Building; iii) Digital Infrastructure; or iv) Strategic Framework (Table 2). The categorization of type of initiative is used to assess composition of initiatives that are technology-led consists of Services & Applications and Digital Infrastructure

category while the holistic type of initiatives consists of Community Building and Strategic Framework category. Finally, type of stakeholders involved in each initiative is coded as i) Government; ii) Private Company; iii) University; or iv) Citizen/NGO (Table 3). Stakeholders information is used to understand collaborative network between types of stakeholders in Putrajaya smart city implementation.

In ensuring reliability and accuracy of code assigned, the coding is performed by two researchers (R1 and R2). First round of coding is done by R1 and then repeated by R2. The codes differences between R1 and

Table 1. Implementation Status Definition

Implementation	Definition
Operational / In Progress	Operational. Also includes initiatives in progress to achieve its desired outcome.
Upcoming	Not started. In the event that no information is found, that particular initiative is coded as upcoming.

Table 2. Types of Initiatives (Adapted: Mora et al., 2019)

Type	Definition
Services & Applications	Initiatives allowing new ICT services and applications to be integrated within the city.
Community Building	Initiatives supporting the design and implementation of the smart city development strategy through raising citizen engagement in the smart city field, stimulating user-driven innovation and community-led urban development, increasing public awareness and digital literacy, informing the city's stakeholders and improving their level of understanding about smart city development and its benefit.
Digital Infrastructure	Initiatives to develop the technological infrastructure necessary to use and benefit from the available ICT services and applications. Examples include the integration of urban operating systems and the construction or extension of high-speed broadband networks and public Wi-Fi networks.
Strategic Framework	Initiatives to develop the city's strategic framework for guiding and regulating smart city development. These activities produce: i) action plans, programs, guidelines, roadmaps; ii) measures proposing standards, evaluation and assessment methods; and iii) workgroups that manage the general course of the smart city development strategy's operations.

Table 3. Types of Stakeholders (Adapted: Mora et al., 2019)

Type	Definition
Government	Local, regional and national governmental authorities and related agencies
Private Company	Businesses which are involved in consultancy activities and/or in the distribution of goods and services
University	Universities and other research and educational institutions
Citizen/ NGO	Citizens and civil society organizations

R2 are reviewed and reconciled to finalize the codes.

Network analysis to study multi-helix collaboration is performed using open source Gephi version 0.10.1 with multimode networks transformation plugin version 1.1.1. An initial network is built on linkages (edges) between initiative (node) and stakeholder (node). Next, the generated network is projected from 2-mode (initiative and stakeholder) to 1-mode (stakeholder). The transformation keeps stakeholder nodes at the beginning and at the end. If two stakeholders have an edge linking them to the same initiatives, they will now have a direct edge between them where the initiative will be evacuated (Grandjean, 2015). The size of node (stakeholder) projected in the network visual is proportionate to its magnitude of engagement.

4. FINDINGS AND ANALYSIS

Findings and analysis are presented in three parts addressing the blueprint conceptualization; completed and in progress initiatives; and future initiatives. Within the second part, the completed initiatives are further elaborated in 4 subsections illustrating Putrajaya command center; data centric initiatives; categories of initiatives; and collaborations & stakeholders.

4.1. Conceptualization of Putrajaya Smart City Blueprint

The journey to create Putrajaya Smart City Blueprint started in June 2017 and implemented in 3 stages namely Stage 1: Assessment and analysis; Stage 2: Formulation of vision, goals, domains and applications based on outcome from Stage 1; and finally Stage 3: Approval. Less than 20 months were taken from the start of conceptualization till approval, laying down 93 initiatives across 7 smart domains (Figure 3). Smart transportation and mobility domain has the highest number of initiatives while the remainder have an equitable share of initiatives to fulfil needs of those domains. In terms of implementation horizon, 25%, 25%, 32% and 18% are categorized as quick win
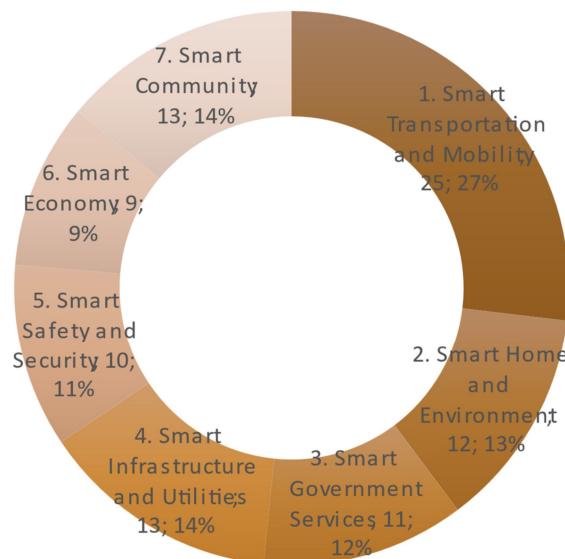

Figure 3. Initiatives in the 7 Smart Domains

(less than 1 year), short term (1-2 years), medium term (3-4 years) and long term (more than 5 years), respectively.

Various stakeholders are involved in creation and delivery of initiatives. Firstly, PLANMalaysia is responsible for providing advisory services to local authority in their smart city blueprint and action plan preparation. According to Head of Smart City Unit in PLANMalaysia for Central Zone, the smart city unit works closely with Perbadanan Putrajaya in planning and development of smart city framework and action plan to enable a systematic smart city development. Secondly, private sectors' representatives and citizens are invited to participate in smart city scope discussion for inputs. In our interview with Perbadanan Putrajaya, senior principal assistant director who heads Putrajaya Smart City Section highlighted that two focus group discussions which involved the private sectors and citizens are held during Stage 1 and Stage 2 of the blueprint creation process to ensure that their inputs are considered in formulating strategy, directions and initiatives to drive Putrajaya smart city. In addition, key stakeholders comprise of internal departments in Perbadanan Putrajaya and relevant agencies and stakeholder are identified for each of the 93 initiatives, as a measure to bring relevant agencies and experts together in implementing action plans. Authors observe that more than half of the initiatives (Table 4) are either extension or enhancement of existing initiatives which underlines the continuity of pertinent initiatives, recognizing there exist outstanding issues that remain important as well as existing solutions that can be leveraged to optimize various solutions.

Table 4. Breakdown of Initiatives

Smart Domains	Existing	Future
1. Smart Transportation and Mobility	11	14
2. Smart Home and Environment	10	2
3. Smart Government Services	9	2
4. Smart Infrastructure and Utilities	7	6
5. Smart Safety and Security	5	5
6. Smart Economy	3	6
7. Smart Community	8	5
Total	**53**	**40**

4.2. Living in a Smarter City: Completed and Operational Initiatives as of 2022

A smart city blueprint can be merely a paper exercise if implemented without systematic planning and execution of its shared visions. Out of the 93 initiatives, 68% of these initiatives is completed and operational as at end of 2022 (interview, March 31, 2023). Four domains (transportation and mobility; government services; infrastructure and utilities; community) recorded completion rate above overall completion rate of 68% while three domains (safety and security; home and environment; economy) are trailing but nonetheless are running at a good progress rate above 50%. Based on authors' observation, new initiatives such as micro mobility, electric vehicle charging stations and eSport community which are not initially in the blueprint were rolled out as part of smart city initiatives. A scope of 73 initiatives (Appendix A) which are completed, in operation and in progress is used for further analysis in the following subsections.

4.2.1. Putrajaya Command Center

Putrajaya smart city 24x7 operations anchor on its command center in monitoring the safety, security, traffic flow, IT

infrastructures and environment of Putrajaya (Figure 4). The integrated command center operations utilizing data and technology encompass information intake and processing, centralized monitoring, response planning and action coordination. This is an epitome of smart services connectedness. According to the senior principal assistant director, when citizens are in distress, citizens can use the 89 physical panic buttons located in the public area or a virtual panic button in Putrajaya Mobile application to seek for help. The requester is then connected directly to the command center which can automatically detect the requester's location and person in charge can further investigate the situation in a real time manner using the nearest CCTV. Then, appropriate response plan is devised and the relevant authorities such as police, civil defence, fire and rescue and hospital are contacted by the command center to take necessary action.

Further monitoring to ensure safety and good traffic flow by utilising 476 CCTVs equipped with Intelligent Video Analytic (IVA) is deployed at strategic places including high risk spots and entry points to Putrajaya. Currently, horn speaker is used as a friendly reminder e.g. when vehicles are parked at illegal area, search rescue, or exposure to risk/danger where these incidents are detected using IVA typologies. Thus, management and operations of safety, traffic and environmental matters in the city are largely efficient and seamless enabled by the smart city smartness created out of data and technology.

4.2.2. Data Centric Initiatives

A high proportion of Putrajaya implemented smart services is data oriented where data is key to power smart applications for city management, propel data driven planning and decision making,
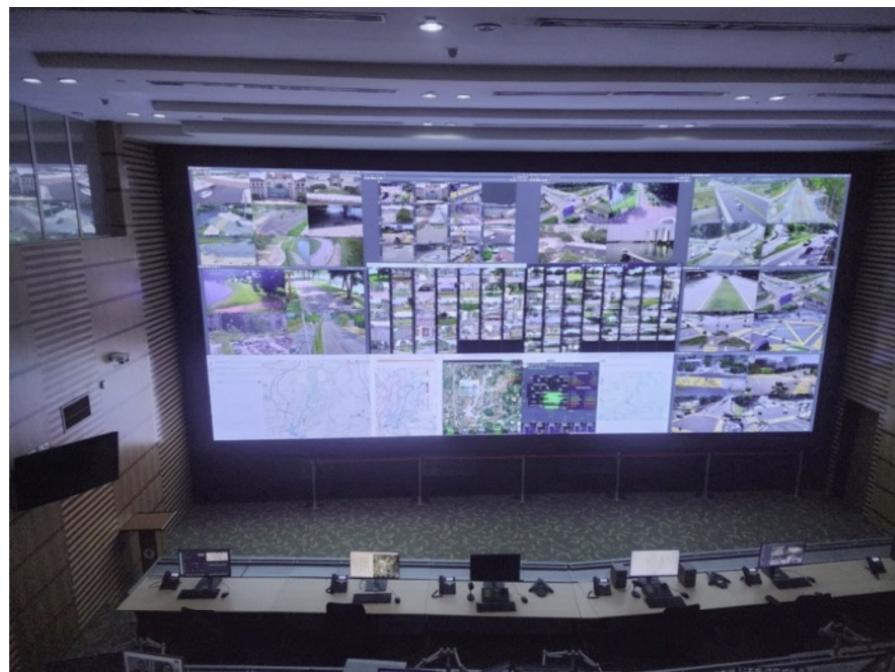
Figure 4. Putrajaya Command Center (Source: Authors with permission)

and enable optimization of current operations. This study found that 49.3% of the initiatives has strong coupling with data. For examples, ride sharing such as Kumpool; e-government services including online business license application, public facility venue booking and online feedback; mobile application for city tourist attraction and promotion of businesses; and monitoring of city security via CCTVs rely heavily on data to operate city management smart services. In addition, for sustainable development strategic planning, wealth of data on traffic count, greenhouse gas emission and carbon reporting is built-in as part of smart city initiatives to support planning to achieve low carbon cities target. Another example of data usage for end to end strategic planning from design to facilities management is seen in adoption of Building Information Modelling in development of Parcel F office (Figure 5) in Precinct 1 (CIDB, 2023).

Similarly, Putrajaya undertakes continuous city lighting optimization in its smart street light system (Figure 6) where sensors are installed to detect faulty lighting point and thereon information is sent to command center, followed by an automated ticket creation to alert the maintenance department to fix the defective lighting point (Perbadanan Putrajaya, 2021b). Transformation of sensor raw data to action-to-fix identified defect, is essentially intelligence logically conceived to run Putrajaya smartly. All in all, Putrajaya's current smart city operations and future needs are closely linked with data centric initiatives that enable services and decision making to be smarter, efficient, and effective.

Figure 6. Smart Street Light with CCTV and Horn Speaker in Precinct 15 (Source: Authors)

4.2.3. Category of Implemented Initiatives

This study found that 75.3% of the implemented initiatives are Services &

Figure 5. Block F5, Parcel F in Precinct 1 (Source: Authors)

Applications based, followed by Community Building, Digital Infrastructure and Strategic Framework based initiatives (Table 5 & Appendix A). Firstly, from Putrajaya's city management perspective, supervisory control and data acquisition (SCADA) for pollution prevention control; lake and wetland management operational system (PLWMOS); and electronic submission of development applications (OSC 3.0) are examples of applications and services designed to monitor pollution level and increase efficiency of building development process, respectively. OSC 3.0 is an online system that manages end-to-end workflow of infrastructure, building plan, landscape plan and renovation application from submission to approval. The complexities of multi-stakeholders involved in the process from submitting applications (public consultant), processing the applications (local authority), providing technical assessment (external agencies such as fire and rescue department) to reporting project progress (public consultant) are streamlined through system workflow which has information captured in a system that's accessible online. Secondly, from citizens' and visitors' perspective, services accessible on smartphone mobile applications and web portal integrates citizens' life into smart city. Transportation application Nadiputra which allows bus riders to obtain bus arrival information and make online payment using digital devices leveraging on nationwide e-wallet and real time payment technology such as DuitNow, Touch n Go, GrabPay and Boost are other examples of digital applications integrated in Putrajaya citizens' lives.

Community building initiatives e.g. GreenROSE@Putrajaya Programme, an 8-month educational and awareness-raising programme on climate change was run to

Table 5. Category of Implemented Initiatives

Initiative Category	No. of Initiatives	Percentage of Initiatives
Services & Applications	55	75.3%
Community Building	10	13.7%
Digital Infrastructure	4	5.5%
Strategic Framework	4	5.5%
Total	**73**	**100.0%**

inculcate low carbon lifestyle among young children (For Tomorrow, n.d.). Neighbourhood watch is another initiative that involves citizen engagement where citizens and enforcement agencies work together to improve home security measures especially during period of high tourist influx (Star Media Group Berhad, 2022). As part of digital infrastructure initiatives, initiatives on fibre cabling upgrade, public WIFI networks and enhancing internet of things (IoT) platform readiness are implemented to catch up with new technology evolvement. Lastly, strategic framework initiatives in developing guidance and regulating Putrajaya smart city development focus on development of action plan, assessment of smart city standard, strategy and operations. Digital Infrastructure Smart Putrajaya Committee was set up to steer digital infrastructure strategy. Furthermore, a dedicated team supporting the operations of the command center is strategically aligned to the Information Technology Department for technical support and to Corporate Communication Department for internal and external agencies liaison.

4.2.4. Collaboration and Stakeholders

Perbadanan Putrajaya (2021c) identified relevant stakeholders since the blueprint stage, acknowledging the importance of collaboration between its internal department

with external agencies and citizens. On average, each implemented initiative involved 4 to 5 stakeholders. Government agencies (including both internal department of Perbadanan Putrajaya and other government agencies) are the most active type of organization in Putrajaya smart city implementation at 49.5%. Private companies' involvement followed closely at 40.2% while NGOs'/Citizens' and Universities' involvement is at 7.5% and 2.8%, respectively (Table 6). Strong participation from government and private companies are represented by dominant blue and green linkages in the network diagram

shown in Figure 7. Internal department of Perbadanan Putrajaya (Smart City Division – SCD; Information Technology and Communication Division- BTMK; Road Division - RD) are the top three most active stakeholders, being the center point of interactions.

Table 6. Types of Organizations Involved

| Type of Organizations	No. of Organizations	Percentage of Initiatives
Government	53	49.5%
Private Company	43	40.2%
Citizen/ NGO	8	7.5%
University	3	2.8%
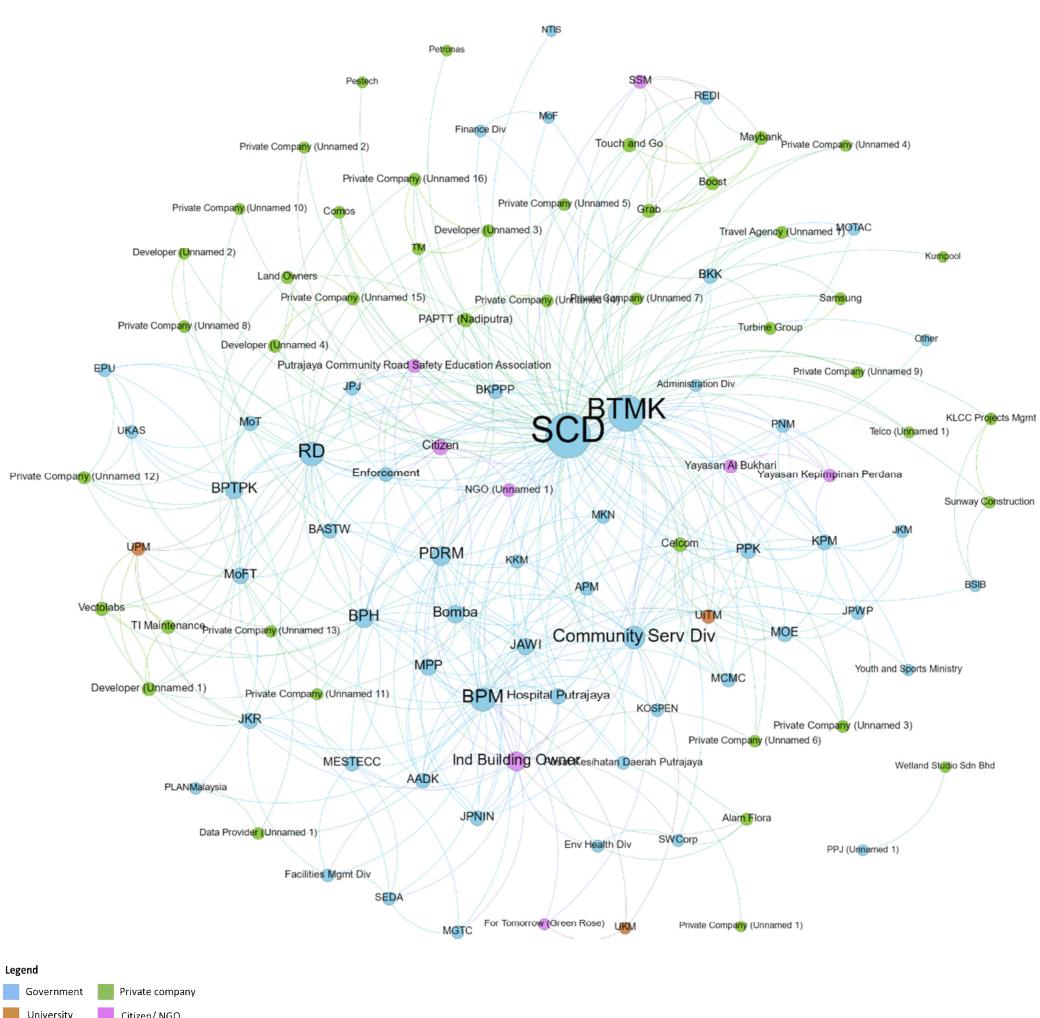
Figure 7. Network Diagram of Stakeholders Collaboration

4.3. Towards an Ambitious Future: Initiatives in Progress and Upcoming

Approximately one third of the blueprint planned initiatives are upcoming for implementation or enhancement to realize its desired outcome. One of the highly anticipated initiatives is the Putrajaya Sustainable Smart City Innovation Hub (Business Today, 2022). The main purposes are to scale up successful techno-digital solutions, improve capability of national entrepreneur and contribute towards nationality sustainability fostered through incubators and live labs in Putrajaya (interview, March 31, 2023). The senior principal assistant director mentioned that in sustaining Putrajaya's operations, locally sourced expertise (currently 80%) is a major consideration in selection of solution and vendor partners as they need to ensure that the operations and maintenance of Putrajaya smart city is self-sufficient while simultaneously help to grow local innovation talents. Commercialization of smart city solutions through proof of concept done in Putrajaya may help other cities to adopt smart cities solutions quicker at a lower cost through locally produced digital solutions unique to Malaysian smart city needs.

5. DISCUSSION AND RECOMMENDATIONS

Arising from the findings, this section discusses themes and recommendations of this study from two perspectives: i) operations management and ii) smart city approaches which cover 4 themes from Mora et al. (2019)'s study on leading European smart cities and 2 themes on Putrajaya unique best practices.

5.1. Operations Management Perspective: Smarter and More Efficient Putrajaya City Operations

In a smart city, strongly integrated components of technology, data and city operation form the smartness foundation. Drawing from the literature of smart city and operations management, there are three operations management areas of interest - efficiency, transparency and involvement (Mak, 2020). From efficiency angle, Putrajaya initiatives around Services & Applications and Digital Infrastructure are concerning physical efficiency of smart city operations while initiatives related to Community Building and Strategic Framework are driving alignment of stakeholder collaborations to gain maximum performance city wide, also known as economic efficiency. Integrated and connected data and technology as seen in CCTV, panic button and city light management initiatives evidenced the coupling of data (obtained from CCTV devices, lighting sensors, connected panic buttons) and technology application (video analytics, automated activation of ticket request to fix faulty light, real time traffic anomalies detection) in running the city operations. Smart services operated through the Putrajaya command center in collaboration with private companies and citizens, has enabled Putrajaya city operations management to be more efficient both physically and economically. This finding expands the conceptualized connection between operations and data by Mak (2020) where essentially this study observed that data needs to work in tandem with technology to materialize operations efficiency. Furthermore, this study found that the other two areas - transparency and

involvement are not as evident as efficiency in Putrajaya case study. There is limited open data initiatives observed despite various data driven initiatives. Despite bottom-up involvements are led and supported by Putrajaya local authority, this study found that there are rooms to increase citizens involvements using technology which in turn will empower citizens to contribute to planning and delivery of smart city.

5.2. Smart City Approach Theme I: Strategic Orientation

Putrajaya smart city is leaning towards technology-led development based on the implemented initiatives. A total of 80.8% of its implemented initiatives are in the Services & Applications and Digital Infrastructure categories. It is imperative to build a solid infrastructure foundation and accessible application platforms to deliver services to citizens, however, a relatively small number of Community Building and Strategic Framework initiatives (19.2%) highlights Putrajaya's gap in terms of holistic vision implementation. Further, Esposito et al. (2021) shows that strategies of smart city should move away from one size fits all. Narrower strategy focusing on technology infrastructure development and digital skilling is fitting for urban setting that's less mature in terms of economic, technological and human capital while holistic strategy might be well suited in national capital or economically prosperous cities. Putrajaya being built as an intelligent federal government administrative city with advanced ICTs, is well suited for holistic strategy. The gap highlighted needs to be understood further and points to further improvement in building a holistic smart city.

Next, efforts to build long term smart city development capacity and sustaining what consists of a holistic Putrajaya smart city are continuous efforts which shall extend beyond the current blueprint. Good governance of smart city literature suggests that this continuous effort should be a living document, evolving through adaptive approach (Mora et al., 2023), an approach that Putrajaya should consider.

5.3. Smart City Approach Theme II: Multi-Stakeholders Collaboration

From our study, starting from public-private collaboration (double helix), a strong working relationship between public-private sector in Putrajaya smart city development is evident. This finding supports Mora et al. (2019) and Thabit & Mora (2023) that public-private sector collaboration is the core engine of smart city development. Participation of private sectors in Putrajaya smart city as the provider of technological smart solutions, delivers the needed solution and simultaneously helps to drive local job employment, hence leading to public value creation.

Smart city literature scholars recommend a quadruple-helix collaboration. In Putrajaya, both the triple helix collaborative model which involves public-private-research relationships and quadruple helix collaboration that represents public-private-research-citizen/NGO actors, are weakly present. While results show that universities and civil organizations are not significantly present in Putrajaya smart city implementation, there is a growing interest in local university research in smart city development and among more NGOs such as Urbanice and Think City in sustainable urban development activities.

Next, we will discuss three recommendations to improve collaboration in Putrajaya smart city context. Firstly, Putrajaya local authority should continue its leadership role as the main architect of Putrajaya smart city but not to be mistaken as the centralized decision maker. Secondly, Putrajaya which has active initiatives in various phases should consider adopting more dynamic and diverse collaborative approaches beyond any fixed form of arrangements in mitigating collaborative challenges. Due to the evolving nature of collaboration, different phases of smart city activity require different configuration of collaborating actors which entails different and multiple roles in the same project. Thirdly, governments often face challenge of effectively engaging citizens in smart city transitions (Mora et al., 2023). This can be improved with provision of effective collaborative tools such as citizen participation platform encouraging citizens to interact and propose ideas; thus, providing the public with clear understanding of smart city initiatives which eventually contributes to a higher level of active citizens' participation (De Guimarães et al., 2020).

5.4. Smart City Approach Theme III: Combination of Top-Down and Bottom-Up Approaches

The scenes of Putrajaya in driving smart city development can be likened to the 'primus inter pares' governance model (Borrás and Edler, 2020) where the local authority of Putrajaya assumes multiple roles exerting top-down influence and supporting bottom-up effort, in implementing government-led and community driven initiatives. Putrajaya local authority acts as the initiator of smart city vision, lead user

that supports creation of a market to find solutions to public needs and also as gatekeeper of infrastructure and technology purchased, controlling both the physical access such as facilities spaces and data access. Both initiator and lead user roles entail active leader roles while gatekeeper role is associated with authority to control. To summarize, these three roles – initiator, lead user and gatekeeper, further reinforce Putrajaya in the leadership role with authority in smart city development.

In formulation of the Putrajaya smart city blueprint, the outcome of a combined top-down and bottom-up approach is a commendable strategic framework. The role of enabler/facilitator of societal engagement assumed by Putrajaya to create a supportive bottom-up approach in encouraging involvement of stakeholders in participatory process, is important in harnessing a community-driven smart city. At present, the community driven effort in implementation of Putrajaya smart city is still far lower than government effort.

5.5. Smart City Approach Theme IV: Balanced Development Across Domains

Putrajaya's initiatives in smart city are well balanced across the domains of mobility, safety, economy, environment, government, community and digital infrastructure (e.g. Giffinger, 2007; Caragliu et al., 2011; Baltac, 2019). The multi-domains strategy is evident in both: i) strategy planning i.e. the Putrajaya smart city blueprint and ii) actual implementation of smart city initiatives. Balanced priority was seen in blueprint initiatives planning (ranging from 9% - 27% per domain) (Figure 3) and in actual implementation (50%-80% per domain as of 2022).

On top of the balanced development across domains, the overarching dimensions of open data infrastructure and overseeing agency of a smart city unit are deemed as favourable conditions of a successful balanced development (Coletta et al., 2019). Putrajaya smart city operates with an overseeing smart city unit since the beginning of smart city planning and throughout implementation, an attribute that further reinforces its role as a gatekeeper of smart city planning and management. Close to 50% of its smart city initiatives have strong coupling with data to run the smart city and/or to provide invaluable insights for decision making. However, this high proportion of data centric and data rich initiatives is not synonymous to having this data open and available for public consumption. This leaves Putrajaya with a wealth of data that remains 'internal', not accessible by outsiders for value creation. Enhancing data 'opening' initiatives for transparency, social and economic value generation should be considered in the future development of Putrajaya smart city.

5.6. Smart City Approach Theme V: Embedded Self Sufficiency and Sustainability

Self-sufficiency and sustainability in the context of Putrajaya are observed in two areas: i) maintainability of deployed ICT solution which involves periodic services, upgrade and potentially major fixes or replacement as time lapsed; and ii) innovation unique to the local scene to continuously address "leftover" or emerging issues. From this study, we learnt that since the beginning of solution selection, consideration of maintainability is given a high importance. The first preference is to

use suitable locally produced technology in order to grow local technology talents and to secure better maintenance support in the long term. Putrajaya smart city development also employs certain non-locally produced solutions but includes training of local support as early as solution selection phase, as a sensible approach in mitigating its maintenance challenges.

A successful city of the future maximizes opportunities to make use of innovation in the form of technological innovation, social innovation and public sector innovation (UN Habitat, 2022b). In Putrajaya, issues such as budget constraint, regulatory requirement, digital security and infrastructure readiness are the main challenges in progressing its smart city agenda (interview, March 31, 2023). Given these challenges, gradual changes and innovation are critical in Putrajaya's smart city evolution as they reinforce its capability to sustain its operations and success as a smart city. While establishing the Putrajaya Sustainable Smart City Innovation Hub is the necessary first step in creating commercial-ready solution using Putrajaya as the living lab, the tangible outcomes are the much-awaited game changer that make-or-break self-sufficiency and sustainability.

5.7. Smart City Approach Theme VI: Cohesion of City Identity and Smart City Strategy

There is evidence of cohesiveness between Putrajaya's original conception and current smart city development plan. From the initiatives planned out in the blueprint, 57% are either extension or enhancement of the existing initiatives. This underlines the continuity of existing initiatives (Table 4) without creating a "shock" to the city.

Similarly, gazetted Putrajaya Structure Plan 2025 which identifies 4 big moves of green, vibrant, distinctive and connected as part of its strategic city direction can be witnessed through smart city initiatives. In response to challenge to prepare the city with adequate facilities to accommodate tourism expansion, digital transformation of tourism including enhancement of experience through mobile application, social media and tourism friendly facilities such as digital board and public amenities are implemented.

6. CONCLUSIONS

Comparing with other cities in Malaysia, Putrajaya is the pioneer in having built-in digital capabilities to be the leading smart city in the nation based on the adopted ISO 37122 standard. From the study, we estimate the progress of Putrajaya is at its target roadmap of Phase 2 (Development Stage) of policy planning and implementation. Comparing Putrajaya against recommended smart city approaches (Mora et al., 2019), Putrajaya's implementation is lagging behind in the holistic strategy and multi-stakeholder collaborative approach. Nonetheless, Putrajaya fares fairly well in its approaches of balanced development across domains and integration of bottom-up approach in its traditional top-down administration style. Putrajaya's approach of embracing self-sufficiency and sustainability in smart city development and preserving cohesiveness of smart city initiatives are the unique Putrajaya's best practices uncovered from this study.

The contribution of this study is three-fold. Firstly, this study captures a frame in time of Putrajaya smart city development conceptualized as many systems that form a comprehensive cosmopolitan of system where the city operations become smarter and more efficient leveraging data and technology. Secondly, this study highlights findings and recommendations for Putrajaya policy makers to improve approaches in planning, designing and development of Putrajaya smart city. Thirdly, it offers novelty of Putrajaya's attributes of self-sufficiency and sustainability embedment, as well as cohesion approach in its smart city transition. These are practical insights that can be considered by other smart city implementation in anticipation of smart city transition and integration challenges.

Quoting Sartre's existentialism concept of "Existence precedes essence" (Aho, 2023), Putrajaya is a unique city that has a predefined special role which is the very reason it is being built (existence). It is charting a path of smart city development that embraces its roots and identity but at the same remains progressive with digital transformation infused with rapid technology advancement. While it remains to be witnessed whether Putrajaya will be a successful city of the future, its journey of smart city development for the pursuit of betterment and maturity as a city, is essentially a dynamic process of self-making in defining itself over time.

There are limitations in this study which are elaborated next. Firstly, while this study has examined progress of implementation from 2018 to 2022, authors acknowledge that this study is not covering the end to end implementation of current Putrajaya smart city blueprint. Authors call for future study to continue evaluation of Putrajaya smart city implementation, especially post 2025 where the current Putrajaya smart city blueprint implementation is expected to complete. Secondly, as the study of smart city

development Malaysia is rather new and unexplored, there is limited sample of smart cities that can be selected. The case study approach has its limitation of being geographically specific. The authors call for the exploration of case studies in different smart cities to further test the study findings and framework.

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ПУТРАЏАЈА КАО ПАМЕТНИ ГРАД: ПУТ КОЈИ ПРАТИ ЊЕНУ ПРОШЛОСТ, САДАШЊОСТ И БЛИСКУ БУДУЋНОСТ

Hsin-Yi Chai, Loo-See Beh

Извод

Ово је прво истраживање спроведено о Путраџаји, административној престоници савезне владе Малезије, које се бави развојем њене текуће, друге генерације паметног града – што до сада није било предмет истраживања. Примењен је студијски приступ случаја како би се испитао специфичан контекст овог водећег модела унапређења паметних градова у Малезији. Циљеви овог истраживања су: i) процена напретка развоја паметног града Путраџаје; ii) упоређивање нивоа усклађености Путраџаје са препорученим приступима развоју паметних градова; и iii) идентификација најбољих пракси које се могу извући из развоја паметног града у Путраџаји. Листа иницијатива преузета из Стратегије за паметни град Путраџаје коришћена је као основа, а додатно је потврђена интервјуима са представницима локалне управе и урбанистима. Поред тога, спроведена је анализа мрежа ради проучавања вишеструке сарадње актера (multi-helix collaboration) уз помоћ отвореног софтвера Gephi. Истраживање је показало да је напредак развоја паметног града у Путраџаји у складу са очекивањима у погледу спровођења иницијатива, да показује уравнотежен развој у различитим областима и укључивање приступа „одоздо нагоре“ у традиционалну администрацију „одозго надоле“. Међутим, уочен је недостатак холистичке стратегије и ограничена сарадња више заинтересованих страна. Путраџаја показује висок ниво самодовољности и унутрашње кохезије у примени иницијатива паметног града, што представља темеље најбољих пракси из којих и други градови могу да уче.

Кључне речи: паметни град; Путраџаја; најбоље праксе; теорија система; управљање операцијама

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APPENDIX A (1/2)

List of Implemented Initiatives

Domain Code	Domain
0. BC	0. Blueprint Creation
1. STM	1. Smart Transportation and Mobility
2. SHE	2. Smart Home and Environment
3. SGS	3. Smart Government Services
4. SIU	4. Smart Infrastructure and Utilities
5. SSS	5. Smart Safety and Security
6. SE	6. Smart Economy
7. SC	7. Smart Community

Type	Type of Initiative
SA	Services and Applications
CB	Community Building
DI	Digital Infrastructure
SF	Strategic Framework

Domain Code	Initiatives	Data Centric	Type	In Blueprint (IB)/ New
0. BC	0.1 Focus group discussion		SF	New
1. STM	1.1 Illegal parking control	Yes	SA	IB
1. STM	1.2 Pay by phone		SA	IB
1. STM	1.3 Automation ticketing and payment system		SA	IB
1. STM	1.4 Cashless bus fare payment system		SA	IB
1. STM	1.5 Dedicated lane for all categories of vehicles		SA	IB
1. STM	1.6 Traffic condition and safety monitoring using smart CCTV	Yes	SA	IB
1. STM	1.7 Multi-lingual bus arrival information	Yes	SA	IB
1. STM	1.8 Real time information on public transport	Yes	SA	IB
1. STM	1.9 Traffic count using smart CCTV	Yes	SA	IB
1. STM	1.10 Motion sensors at night for energy saving	Yes	SA	IB
1. STM	1.11 Sensor to monitor real time facility problem	Yes	SA	IB
1. STM	1.12 Bike sharing facilities and services		SA	IB
1. STM	1.13 Ride sharing	Yes	SA	IB
1. STM	1.14 Eco ride for tourists		SA	IB
1. STM	1.15 NGV and EV buses		SA	IB
1. STM	1.16 Improvement of bicycle lane and pedestrian walkways		SA	IB
1. STM	1.17 Rail Based Transport (MRT/LRT)		SA	IB
1. STM	1.18 Micro mobility		SA	New
2. SHE	2.1 Weather monitoring (temperature, rainfall, windspeed, humidity)	Yes	SA	IB
2. SHE	2.2 Supervisory control and data acquisition (SCADA) for pollution prevention control	Yes	SA	IB
2. SHE	2.3 Putrajaya lake and wetland management operational system (PLWMOS)–- lake water quality, flora and fauna	Yes	SA	IB
2. SHE	2.4 Malaysian Urban Rural National Indicators Network for sustainable development	Yes	SF	IB
2. SHE	2.5 Real time energy use monitoring for buildings (including solar PV performance)	Yes	SA	IB
2. SHE	2.6 Building Sector Energy Use & Carbon Reporting Programme (BECO2R) for non-residential building (online system & apps)	Yes	SA	IB
2. SHE	2.7 City scale GHG inventory system	Yes	SA	IB
2. SHE	2.8 IoT platform		DI	New
2. SHE	2.9 EV charging station		SA	New
3. SGS	3.1 Putrajaya command centre	Yes	SA	IB
3. SGS	3.2 Putrajaya mobile apps	Yes	SA	IB
3. SGS	3.3 Digital information boards at strategic areas for latest news/ events/ promotions		SA	IB
3. SGS	3.4 Electronic submission of development applications (OSC 3.0)		SA	IB
3. SGS	3.5 Complaints online	Yes	SA	IB
3. SGS	3.6 Payment online		SA	IB
3. SGS	3.7 Online license application	Yes	SA	IB

APPENDIX A (2/2)

List of Implemented Initiatives

3. SGS	3.8 Online booking venues	Yes	SA	IB
3. SGS	3.9 Online registration system for events	Yes	SA	IB
4. SIU	4.1 Centralized radio access (C-RAN)		DI	IB
4. SIU	4.2 Free public WiFi		DI	IB
4. SIU	4.3 Fibre cabling		DI	IB
4. SIU	4.4 Energy saving street light		SA	IB
4. SIU	4.5 Building integrated modelling (BIM)	Yes	SA	IB
4. SIU	4.6 City lighting management	Yes	SA	IB
4. SIU	4.7 Material recovery facility		SA	IB
4. SIU	4.8 Digital infrastructure smart Putrajaya committee		SF	New
5. SSS	5.1 Panic Buttons	Yes	SA	IB
5. SSS	5.2 Putrajaya command centre	Yes	SA	IB
5. SSS	5.3 Smart CCTV for safety surveillance	Yes	SA	IB
5. SSS	5.4 Neighbourhood watch		CB	IB
5. SSS	5.5 Speed awareness design	Yes	SA	IB
5. SSS	5.6 Social media monitoring	Yes	SA	New
5. SSS	5.7 Public health monitoring (Covid-19 dashboard)	Yes	SA	New
5. SSS	5.8 Dedicated support team in command center		SF	New
6. SE	6.1 E-wallet and e-kiosk		SA	IB
6. SE	6.2 Smart application for city attraction	Yes	SA	IB
6. SE	6.3 Tourism feedback	Yes	SA	IB
6. SE	6.4 Smart application to view, sell and buy properties	Yes	SA	IB
6. SE	6.5 Digital billboards		SA	IB
6. SE	6.6 Smart application for business promotion	Yes	SA	IB
6. SE	6.7 Set up incubator/ lab to encourage business community to adopt technology	Yes	CB	IB
6. SE	6.8 Wetland studio		CB	New
7. SC	7.1 Awareness program		CB	IB
7. SC	7.2 Digital library		CB	IB
7. SC	7.3 Online school admission		SA	IB
7. SC	7.4 Digital classroom		CB	IB
7. SC	7.5 Innovative center		CB	IB
7. SC	7.6 Children led climate change adaptive programme		CB	IB
7. SC	7.7 Healthy diet information and education		SA	IB
7. SC	7.8 Information for dengue hotspot area	Yes	SA	IB
7. SC	7.9 Putrajaya bebas asap rokok (smoke free)		SA	IB
7. SC	7.10 City YouTube channel		SA	IB
7. SC	7.11 Community interaction platform	Yes	CB	IB
7. SC	7.12 eSport		CB	New