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Are Philippine Cities Ready to Become Smart Cities?

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List of Acronyms

3D	three dimensional
4G	fourth generation
ADMU	Ateneo de Manila University
AI	artificial intelligence
ARTA	Anti-Red Tape Act
ASEAN	Association of Southeast Asian Nations
ATM	automated teller machine
BERDE	Building for Ecologically Responsive Design Excellence
BPS	Bureau of Philippines Standards
CBP	Central Business Portal
CCTV	closed-circuit television
COA	Commission on Audit
COVID-19	coronavirus disease 2019
CRADLE	Collaborative Research and Development to Leverage Philippine Economy
CSR	corporate social responsibility
DAP	Development Academy of the Philippines
DBP	Development Bank of the Philippines
DENR-EMB	Department of Environment and Natural Resources-Environment Management Bureau
DICT	Department of Information and Communications Technology
DILG	Department of the Interior and Local Government
DLPC	Davao Light and Power Company
DOST-PCIEERD	Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technology Research and Development
DOTr	Department of Transportation
eBOMS	Electronic Budget Operations and Monitoring System

EO	Executive Order
FOI	Freedom of Information
GIS	geographic information system
GODDESS	Good Governance through Data Science and Decision Support System
GSM	global system for mobile communications
HUC	highly urbanized city
IBPAP	Information Technology and Business Process Association of the Philippines
iBPLS	Integrated Business Permits and Licensing System
ICT	information and communications technology
ID	identity documents
IMD	Institute for Management Development
IoT	Internet of Things
IP	internet protocol
ISO	International Organization for Standardization
IT	information technology
IT-BPM	information technology and business process management
JICA	Japan International Cooperation Agency
LAN	local area network
LANDBANK	Land Bank of the Philippines
LED	light-emitting diode
LGU	local government unit
LPC	Leechiu Property Consultants
LTE	long-term evolution
MOA	memorandum of agreement
MCDCB	Metro Cebu Development and Coordinating Board
NBP	National Broadband Program
NGAs	national government agencies
NPC	National Privacy Commission
P2P	point-to-point

PCOO	Presidential Communications Operations Office
PDP	Philippine Development Plan
PhilHealth	Philippine Health Insurance Corporation
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PHLPost	Philippine Postal Corporation
PHP	Philippine peso
PNS	Philippine National Standard
PPP	public-private partnership
PSA	Philippine Statistics Authority
PSSCC	Public Safety and Security Command Center
QR	quick response
RA	Republic Act
SME	small and medium enterprise
SPARTA	Smarter Philippines through Data Analytics Research and Development, Training and Adoption
SRP	South Road Properties
STI	science, technology, and innovations
Tech4ED	Technology for Education, Employment, Entrepreneurs, and Economic Development
TKC	Tanod Kontra COVID
TORCH	Taguig Online Resources and Community Hub
UAE	United Arab Emirates
UP	University of the Philippines

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Abstract

Smart city development is recognized as a potential solution to urbanization issues. This study examines Philippine cities' readiness for smart city development by answering three policy questions: (1) What drives Philippine local government units toward implementing smart city initiatives; (2) What is the extent of smart city development among Philippine cities; and (3) How can the Philippine government facilitate the development of smart cities? A desk review of smart city initiatives in some Philippine cities was carried out, and interviews were conducted with local government units, national government agencies, businesses, and development organizations. It finds that the Philippines has started to tread the path toward building smart cities, and some cities already exhibit readiness. However, additional pathways to smart city development must be paved. There is a need to address funding, data management, and sustainability challenges. Addressing the challenges not only requires actions at the local level but also demands additional support from the national government in developing policies and standards to improve data flow, promoting technology- and innovation-powered cities, and ensuring transparency and accountability in the implementation of smart city initiatives.

Introduction

Smart city development has the potential to solve many urbanization issues. Given the persistent and glaring challenges faced in urban areas, this idea warrants a discussion. More so for the Philippine urban scene, where numerous problems have persisted over time despite its potential for development.

Based on the 2015 Census of Population (PSA 2019), most Filipinos reside in the country's urban areas. While the population size in the country's urban areas allows local government units (LGUs) to leverage human capital, it can also bring about governance issues. Some reviews on the country's urbanization progress revealed limited benefits, such as expensive, inefficient, and slow business transactions; costly telecommunication services; unreliable and costly access to electricity and water; traffic issues; and weak innovation (see Baker et al. 2017). The situation has become more challenging with climate change and the recent coronavirus disease 2019 (COVID-19) pandemic. Persisting urbanization challenges, which have become more apparent with the onslaught of disasters and the pandemic, require innovative solutions, such as smart city development.

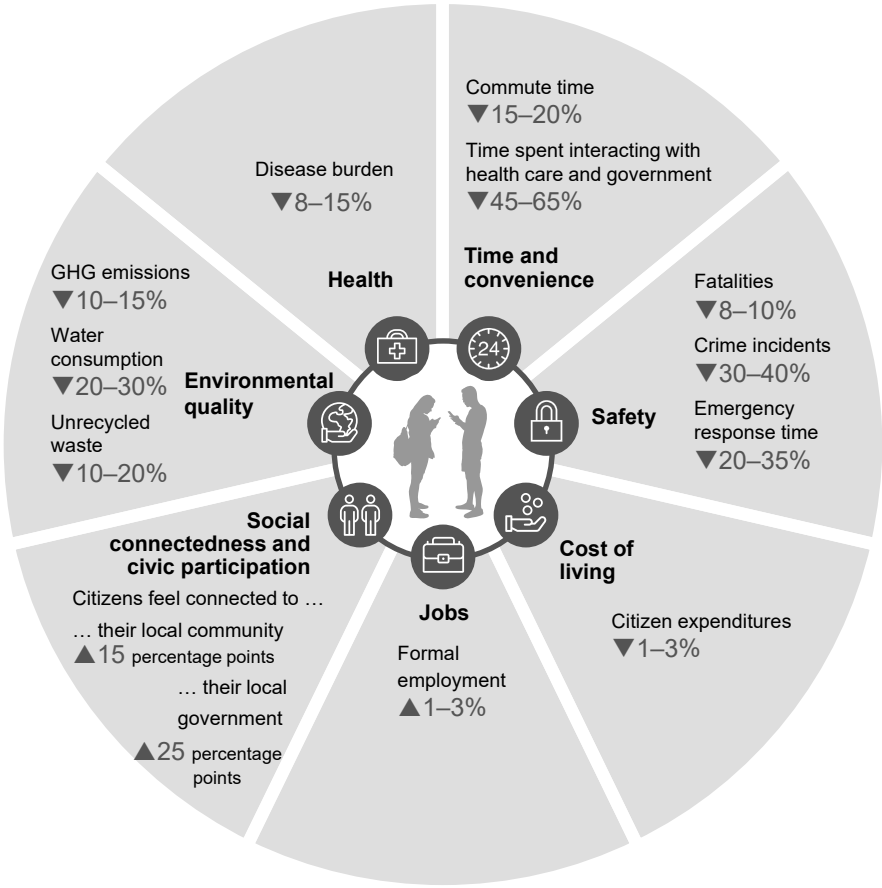
Some studies have provided estimates and evidence on the impact of smart city initiatives. Peng (2019) assessed the impact on urban competitiveness (i.e., economic, sustainable development, and livability) through regression using 2017 data from 294 Chinese prefecture-level cities. She showed that (1) information economy is positively associated with economic competitiveness and sustainable development competitiveness, (2) development of a network society is positively associated with economic and livability competitiveness, (3) development of an online government is positively associated with economic competitiveness, and (4) development of digital life is positively associated with sustainable competitiveness.

Another study on the impact of smart city initiatives was conducted by Wu et al. (2020), who tested the impact of smart city initiatives in 90 prefecture-level cities in China on health-related variables using difference-in-difference and propensity score matching methods. Wu et al. (2020) showed that building smart cities is positively associated with (1) enhanced health status, (2) enhanced health status through a reduction

in the utilization of outpatient services, and (3) enhanced health status through an increase in the use of inpatient services.

Woetzel et al. (2018) provided estimates on the impact of smart city applications on quality of life dimensions (Figure 1). More specifically, they estimated the capacity to enhance baseline metrics by 2025 with various technologies based on research papers, industry reports, publicly available case studies, and McKinsey case studies and data sets.

Figure 1. Estimated impact of smart city applications on indicators of quality of life



GHG = greenhouse gas
Source: Lifted in full from Woetzel et al. (2018)

Generally, positive estimates are apparent in their quality of life dimensions. Their study also provided insights on potential issues such as disruptions in some industries due to higher expectations on products and services, higher need for data protection and security, and large-scale commitments to frequently advancing technology.

Overall, the findings of the cited studies are insights to consider in determining whether to implement smart city initiatives.

The numerous potential benefits of smart city development seem to attract LGUs in the Philippines. Some LGUs have already attempted to address urban challenges with smart city solutions. Some (e.g., city governments of Manila, Cebu, Davao) have also participated in the Association of Southeast Asian Nations (ASEAN) Smart Cities Network (Ludher et al. 2018). While such steps have been taken, there is uncertainty about the fate of these initiatives. Aspiring smart cities should be capable of undergoing the development required; otherwise, efforts may be premature and not worthwhile. The uncertainty on this capacity can be related to the lack of studies determining whether Philippine cities are prepared for smart city development.

This study aims to fill the literature gap by understanding the concept of smart cities in the context of Philippine cities and answering three policy questions:

1. What drives Philippine cities toward implementing smart city initiatives?
2. What is the extent of smart city development among Philippine cities?
3. How can the Philippine government facilitate the development of smart cities?

Determining the motivations and enablers is important to validate the expectations of LGUs from smart city initiatives, ensuring that efforts are targeted to achieve what are believed to be possible outcomes of smart city development. Meanwhile, knowing the extent of smart city development would prove that cities can employ such initiatives. Furthermore, identifying challenges faced in implementing the initiatives would help provide recommendations on how the Philippine government can move forward in smart city development.

Understanding the Smart City Concept

Discussions on smart cities have increased over time. Based on Stübinger and Schneider's (2020) systematic review of 200 Google Scholar publications, there was already initial smart city research in the 1970s following the Los Angeles Community Analysis Bureau's production of data reports on housing quality and demographics using infrared aerial photography and cluster analysis. Stübinger and Schneider (2020) observed that the number of articles on smart cities had an exponential growth following the first Smart City Expo World Congress in 2011. They noted that there had been around 200,000 articles published each year.

In the Philippines, the term "smart city" has been used by some LGUs in describing their policies and activities. "Smart city", as used by the LGUs, evokes a utopia—a local sphere with numerous positive developments that will significantly benefit the constituents. As much as constituents would want to live in such an ideal city, a disconnect comes with the vagueness of smart city elements and pathways. The term "smart city" has been defined internationally and even domestically; nevertheless, the variety of definitions adds to the complexity of the concept, and further discussion is needed to tease out its elements with the Philippine context in mind.

The Bureau of Philippines Standards (BPS 2020, p.2), as reflected in the Philippine National Standard (PNS) ISO 37122:2020, has adopted the International Organization for Standardization (ISO) definition of a smart city—that is, "city that increases the pace at which it provides social, economic, and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment".[1]

[1] PNS ISO 37122:2020 classifies smart city indicators into the following categories: (1) economy, (2) education, (3) energy, (4) environment and climate change, (5) finance, (6) governance, (7) health, (8) housing, (9) population and social conditions, (10) recreation, (11) safety, (12) solid waste, (13) sport and culture, (14) telecommunication, (15) transportation, (16) urban/local agriculture and food security, (17) urban planning, (18) wastewater, (19) water, and (20) reporting and record maintenance (BPS 2020).

While the "smart city" term is already defined in the PNS, a working definition is created for this research, categorizing keywords with existing literature as references to understand the concept further in the context of the Philippines. Constructing a working definition of a "smart city" requires a review of existing definitions, such as that of Ramaprasad et al. (2017). The unified definition provided by Ramaprasad et al. (2017) is a reasonable starting point, as it is straightforward and flexible enough to be validated and modified if necessary (Figure 2). Made up of 25,200 potential elements, the unified definition was derived using an ontology, in which greater than 36 definitions were deconstructed and assessed (Ramaprasad et al. 2017). It is altered in this research based on a review of international and domestic definitions.

Figure 2. Unified definition of smart city

Smart								City			
Structure		**Functions**		**Focus**		**Semiotics**			**Stakeholders**		**Outcomes**
Architecture	[to]	Sense	[+]	Cultural	[+]	Data		[by/from/to]	Citizens	[for]	Sustainability
Infrastructure		Monitor		Economic		Information			Professionals		Quality of life
Systems		Process		Demographic		Knowledge			Communities		Equity
Services		Translate		Environmental					Institutions		Livability
Policies		Communicate		Political					Businesses		Resilience
Processes				Social					Governments		
Personnel				Technological							
				Infrastructural							

Source: Lifted in full from Ramaprasad et al. (2017)

Reviewed definitions reflect that an innovative and technology-powered system is suitable for handling data, information, and/or knowledge in an aspiring smart city. The Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD n.d.-a, p.4) defines smart city as "an ecosystem comprised of people, organizations and businesses, policies, laws, and processes integrated together to create desired outcomes… The city is adaptive, responsive, relevant, and integrates technology to accelerate, facilitate, and transform this ecosystem." Several other papers also emphasize technology's importance in a smart city (see Nam and Pardo 2011; Albino et al. 2015; Elgazzar and

El-Gazzar 2017; Ludher et al. 2018; McKinsey Global Institute 2018; DICT 2019a; Sánchez-Corcuera 2019; Yoon et al. 2020).

Meanwhile, the definition of a smart city in the ASEAN Smart Cities Framework has an innovation aspect: "A smart city in ASEAN harnesses technological and digital solutions as well as innovative non-technological means to address urban challenges, continuously improving people's lives and creating new opportunities" (Ludher et al. 2018, p.12). The importance of technology and innovation in implementing smart city initiatives makes these themes inseparable from the system.

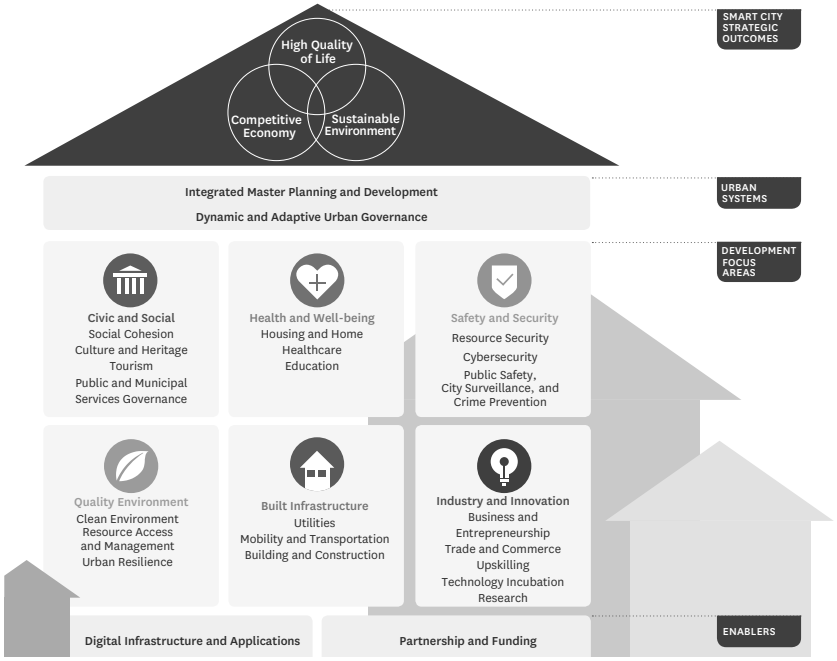
Reviewed definitions of smart cities are not specific to the functions of the innovative and technology-enabled system. The general thought derived from other definitions is that usage of the system would help people (see Albino et al. 2015; Elgazzar and El-Gazzar 2017; Ramaprasad et al. 2017; Ludher et al. 2018; McKinsey Global Institute 2018; DICT 2019a; Sánchez-Corcuera 2019; Yoon et al. 2020).

Since utilization covers the functions provided in the unified definition of Ramaprasad et al. (2017) and technologies will not be able to inform policymakers and implementers on the optimal solutions to urban problems without data, information, and/or knowledge, the corresponding terms shall be included in the working definition for this research.

In terms of concentration, Ludher et al. (2018) identified focus domains (i.e., built infrastructure, quality environment, industry and innovation, safety and security, health and well-being, and civic and social), as reflected in the ASEAN Smart Cities Framework (Figure 3). Those domains are similar to the themes found in other literature, such as the identified focus areas of Ramaprasad et al. (2017) and the smart city action fields of Yoon et al. (2020). They are consistent with the 2017–2022 Overall Strategic Framework of the *Philippine Development Plan* (PDP). Consequently, keywords under "focus" in the working definition shall be patterned from the ASEAN Smart Cities Framework's development focus areas.

Stakeholders are very crucial to the process of building smart cities, as they cannot be taken away from the equation. The importance of stakeholders, including businesses, organizations, and people, is apparent in the smart city definition from DOST-PCIEERD (n.d.-a).

Figure 3. ASEAN Smart Cities Framework



ASEAN = Association of Southeast Asian Nations
Source: Lifted in full from Ludher et al. (2018)

The significance of people in creating smart cities is also evident in several other reviewed literature (see Nam and Pardo 2011; Albino et al. 2015; Ramaprasad et al. 2017; Ludher et al. 2018; Sánchez-Corcuera 2019). Reviewed literature on enablers to be presented in succeeding discussions also reflect the value of stakeholder engagement in smart city development.

According to literature, smart city initiatives can lead to innovation, sustainability, and efficiency. Yoon et al. (2020) found innovation, sustainability, and efficiency to have high coverage in their review of Asian smart city models. Toli and Murtagh (2020) also found efficiency as an objective in their analyses of smart city definitions. Meanwhile, sustainability as an outcome was mentioned in the papers of Elgazzar and El-Gazzar (2017), Ramaprasad et al. (2017), Ludher et al. (2018), and Toli and Murtagh (2020). Thus, innovation, sustainability, and efficiency concepts were considered in formulating the working definition of smart city.

Other potential outcomes include competitiveness, inclusiveness, and economic growth, which are found in related literature. The definitions of smart sustainable city from Kondepudi (2014) and DOST-PCIEERD (n.d.-a) include enhanced competitiveness as an outcome. Additionally, the proposed definition by Toli and Murtagh (2020) highlights the availability of economic growth opportunities in smart cities. Furthermore, the inclusion of equity in the unified definition from Ramaprasad et al. (2017) can be connected to inclusiveness. Inclusiveness, as well as economic growth and competitiveness, is an important goal among Asian countries. Yoon et al. (2020) highlighted the higher coverage of the three outcomes in Asian smart city models than non-Asian smart city models. The great relevance of competitiveness, inclusiveness, and economic growth to the context results in the need to capture such concepts in the working definition.

Likewise, related literature shows smart city initiatives can enhance quality of life, resilience, and governance. Numerous papers have discussed the enhanced quality of life as an outcome (Ramaprasad et al. 2017; McKinsey Global Institute 2018; Toli and Murtagh 2020; and Yoon et al. 2020). Furthermore, the Department of Information and Communications Technology (DICT 2019a) emphasizes the improvements that smart cities can bring to citizens' welfare and well-being. The emphasis on quality of life is understandable, as the smart city concept heavily involves addressing the needs of people. Meanwhile, in terms of governance, Toli and Murtagh (2020) found some smart city definitions that cover the objective. Aside from governance and quality of life, resilience is included in the smart city unified definition by Ramaprasad et al. (2017). However, Yoon et al. (2020) noted the lack of discussion on resilience in the Asian smart city models they reviewed. Their finding is surprising, given that many Asian countries are still developing and are prone to disasters. The Philippines, in particular, should be observant of the impact of smart city initiatives on resilience, given the shocks that it should be able to absorb. Given the information, improving quality of life, governance, and resilience should be considered in formulating the working definition.

Outcomes of smart city initiatives can be grouped into three categories as provided in the ASEAN Smart Cities Framework presented by Ludher et al. (2018): (1) high quality of life, (2) competitive economy,

and (3) sustainable environment. The Venn diagram shown in Figure 3 is open to subthemes that may arise from merging the two or three categories. It gives the idea that the outcomes of smart city initiatives are not necessarily exclusive of each other.

Working definition

Given the structure, functions, focus, semiotics, stakeholders, and outcomes based on the literature reviewed, a working definition is formulated in this research. The unified definition presented by Ramaprasad et al. (2017) was altered based on a review of local and international definitions of "smart city". Alterations to the unified definition were made following the review, leading to the working definition in Figure 4. The working definition defines "smart city" as a technology and innovation-powered system that senses, monitors, processes, translates, and communicates industry and innovation, built infrastructure, quality environment, safety and security, health and well-being, and civic and social data, information, and knowledge by, from, or to people and institutions for sustainable environment, competitive economy, and high quality of life (Figure 4).

Figure 4. Working definition of "smart city"

Smart								City		
Structure		**Functions**		**Focus**		**Semiotics**		**Stakeholders**		**Outcomes**
Technology and innovation-powered system	[to]	Sense Monitor Process Translate Communicate	[+]	Civic and social Health and well-being Safety and security Quality environment Built infrastructure Industry and innovation	[+]	Data Information Knowledge	[by/from/to]	People Institutions	[for]	High quality of life Competitive economy Sustainable environment

Source: Authors' compilation based on reviewed literature

Along with the working definition, smart city development phases can add another layer to the analysis of the initiatives being conducted by aspiring smart cities. World Bank (2021) describes the three smart city development phases as follows:

1. The **infrastructure phase** comprises technological and physical infrastructure such as geospatial information, ICT,

and city infrastructure. Smart city infrastructure is generally software, including ICT (communication infrastructure); however, the development requires urban hardware (e.g., construction of buildings). Geospatial information infrastructure is usually used to converge cyberspace and real space.

2. The **data phase** comprises data sharing and the Internet of Things (IoT). The emphasis here is on data collection through various sensors and the sharing and use of produced data. Under this phase, a common open platform for related tasks and functions should be constructed aside from developing individual functions and service intelligence.
3. The **service phase**, the completion stage of a smart city, comprises city innovation, algorithm, and service. Algorithms and services include city services using algorithms that crunch and analyze data, while city innovation relates to social environments and institutions that enable new services and ideas to solve urban issues. In this phase, cities already share information like organisms, and the future city wherein there is urban transformation can be envisioned.

Initiatives may be implemented randomly across the smart city development phases, but the succession of phases from infrastructure to data to service as in the order enumerated by the World Bank (2021) is the most logical, given that the preceding phase(s) facilitate the development of succeeding phase(s). For instance, data collection and sharing would be difficult to implement if the city or municipality does not have the infrastructure to speed up the process. Service-oriented initiatives might not properly address constituents' needs without sufficient data. Given potential limitations that may occur with the random implementation of initiatives across the phases, attention should not only be given to the existence of initiatives within each phase but also to the succession of the phases.

Review of Literature: Enablers, Barriers, and Pathways to Smart City Development

Enablers, barriers, and pathways

Enablers

In building smart cities, LGUs should assess the readiness of their respective cities to carry out related activities in terms of the presence of enablers. Enablers are catalysts for implementing smart city initiatives, similar to inputs in a theory of change. They may be necessary or sufficient to implement the initiatives successfully. Since there are not many pieces of evidence, distinguishing between necessary and sufficient enablers is challenging. Nevertheless, this study attempts to make an initial distinction based on related literature and analysis.[2]

One enabler mentioned in related literature is having a vision of what a city can become through smart city initiatives. For instance, Woetzel et al. (2018) regard a leap of imagination as a requirement for smart cities, where vision is a guide and enthusiasm is the fuel for the initial step. Jayasena et al. (2019) also emphasized vision and goals as key enablers by reviewing 52 literature projects, websites, conference proceedings, and other reports. Based on literature and analysis, vision is considered a necessary enabler. The current vagueness of the term "smart city" requires government units to clearly define what relevant initiatives can do for the constituents and why efforts to have smart cities should be exerted. At the end of the day, LGUs with a vision of smart transformation are one step closer to becoming smart cities.

Population as an enabler was also explored, although there is a lack of literature on the matter. Nevertheless, McKinsey Global Institute (2018) described archetypes of cities in Southeast Asia as follows:

1. Agile seedbeds have less than a million population, enabling a fast implementation of pilots and scaleups of smart city applications.

[2] The term "enablers" is used instead of "drivers", which was the term used by Jayasena et al. (2019), Veselitskaya et al. (2019), and Tan and Taeihagh (2020). This is to prevent confusion with the word "drivers" in terms of motivations of aspiring smart cities to initiate efforts related to smart city development.

2. Emerging champions are midsized, with limited financial capacity to suffice the required large-scale investment and with infrastructure that can benefit from more integrative solutions.
3. Prime movers are Southeast Asia's biggest primary cities with large inefficiencies and exhausted social and physical infrastructure systems, wherein smart city initiatives, even at modest levels of adoption, are easily feasible.
4. Smart city sandboxes are cities with numerous smart applications that capture each urban life domain and with integrated and strong high-speed communication networks.

The discussion does not necessarily discriminate in terms of the capacities of cities to successfully implement smart city initiatives, given their population size. Although population is not an enabler, it would have to be considered in implementing smart city initiatives because of its potential implications.

Economic status appears to influence smart city development. According to Woetzel et al. (2018), income influences the pace at which aspiring smart cities transform. Among the 50 cities whose deployment of smart city initiatives they assessed, richer cities generally had a faster pace of transformation. Meanwhile, Tan and Taeihagh (2020) noted stability in economic progress as an enabler based on their systematic review of 56 studies. Despite these findings, being a wealthy city should not be considered necessary in implementing smart city initiatives, especially when LGUs have good stakeholder management.

Related literature shows LGUs can leverage their engagements to become smart cities, including financing. Jayasena et al. (2019) emphasized the importance of considering stakeholders to be engaged in governance. Tan and Taeihagh (2020) added that knowledge transfer and participation from the private sector are enablers of smart city development. Engagements with stakeholders also open opportunities in terms of financing relevant projects. In the study of Woetzel et al. (2018), the government owned 70 percent of the assessed smart city applications. However, they added that 60 percent of the initial investment could come from the private sector. Veselitskaya et al. (2019), who looked at four city cases, also highlighted public-private partnerships (PPPs) as an enabler of smart city development. Aside from private sector partnerships,

LGUs aiming to build smart cities should be closely in touch with their constituents to acquire an in-depth knowledge of the latter's needs. Meanwhile, Woetzel et al. (2018) emphasized that becoming a smart city requires having the capacity to respond to people's needs. The importance of good stakeholder engagement based on the reviewed literature makes the enabler necessary for building smart cities.

The presence of technology infrastructure in smart city aspirants is also a key enabler. Tan and Taeihagh (2020) identified technology and infrastructure readiness as an enabler of smart city development. Woetzel et al. (2018) even refer to the technology base as the building blocks required before deploying smart city applications. The base includes numerous smartphones and other sensors connected through fast communication networks and open data platforms (Woetzel et al. 2018). The following are smart city indicators according to PNS ISO 37122:2020: (1) number of available digital learning devices for every 1,000 students; (2) average information technology infrastructure downtime; (3) percentage of population able to access fast broadband connection; (4) percentage of area under dead spot, white zone, or without telecommunication connectivity; and (5) percentage of area with internet connection provided by the LGU (BPS 2020). Technology infrastructure is at the heart of smart cities, as depicted in the related literature, making it a necessary enabler to becoming a smart city.

Regulations are also enablers in implementing smart city initiatives. Hence, the regulatory environment should be strong to build the trust and confidence of investors and constituents (Tan and Taeihagh 2020). Furthermore, given the expected abundance of data derived from smart city initiatives, data security and protection policies must be implemented before deploying the activities. It must be emphasized that data protection and security will not only prevent abuses of data usage but also encourage constituents to participate in data provision. The potential benefits of establishing regulations, such as data protection and security, turn the policies into necessary enablers of smart city development.

Human capital is another necessary enabler of smart city initiatives. Despite being technologically inclined, smart cities will not run without the right people. PNS ISO 37122:2020 even has the following relevant smart city indicators: (1) percentage of the labor force

in the ICT sector and (2) percentage of the labor force in research and development and education sectors (BPS 2020). Hence, governments must tap people who are technically knowledgeable and competent (Tan and Taeihagh 2020).

However, Woetzel et al. (2018) argued that while new roles (e.g., data science team, analytics unit, chief digital officer) have been created to implement the initiatives, the government's efforts must be diffused in all government aspects. The authors discussed further that municipal agencies are not exempt from understanding, directing, and monitoring the programs, even if the agencies depend on external providers to install and operate new systems. They added that the city government has to implement its own intelligent solutions while supervising the development of the ecosystem. Human capital is therefore needed, even within the LGU organizational structure. Overall, LGUs should work on developing internal human capital suitable for smart city development.

Barriers

Barriers are problems or issues that cities must overcome to implement and sustain smart city initiatives. Cities lacking necessary enablers are expected to run into such barriers. Indeed, many identified obstacles to smart city development relate to the lack of the enablers mentioned earlier. For instance, Tan and Taeihagh (2020) cited the lack of the following as obstacles: citizen participation, human capital, regulatory safeguards and governance frameworks for smart cities, readiness of technology-related infrastructure, and funds. Meanwhile, Jayasena et al. (2019) cited the lack of the following as barriers: established relationships between stakeholders, organization in funding structures, capital, competency and knowledge, and technology. Additionally, Veselitskaya et al. (2019) cited the lack of information security as an obstacle. Identifying the abovementioned barriers also emphasizes the roles of the characteristics as enablers of smart city development.

Other barriers have also been identified in related literature. Veselitskaya et al. (2019) noted conflict of interest as an additional barrier. Since different groups might have different takes on relevant projects, the success of smart city initiatives may depend on the power dynamics. Thus, stakeholder engagement must be strengthened by

LGUs to reduce uncertainty. Meanwhile, Jayasena et al. (2019) identified political uncertainties as barriers, implying the need for sustainability mechanisms in aspiring smart cities. In addition to other obstacles, Tan and Taeihagh (2020) noted that fragmented authority, insufficient investment in basic infrastructure, lack of constituents' knowledge and understanding of technology, environmental concerns, and inclusivity are also barriers. Given the barrier of fragmented authority, a central authority and strong stakeholder engagement are thus essential (Tan and Taeihagh 2020). The tagging of insufficient investment in basic infrastructure as an obstacle implies that the foundation has to be in place to support the adoption of smart city tools.

Meanwhile, the inclusion of insufficiency in constituents' knowledge and understanding of technology emphasizes that information dissemination to the public should be considered as a step in implementing smart city initiatives. Regarding environmental concerns as barriers, Tan and Taeihagh (2020) explained that smart city development leads people to migrate from rural to urban places, which can lead to abrupt ecological stress on the environment. Meanwhile, identifying the lack of inclusivity as a barrier implies that smart cities should not only address the needs of select people but all individuals. The identified additional obstacles should be considered to help prevent disruptions in smart city developments.

Pathways

Similar to activities in a theory of change, good pathways facilitate the transformation of inputs into outputs and outcomes. These steps support smart city development. Necessary enablers may become involved in the pathways because of the need to retain these inputs to achieve the intended outcomes of smart city initiatives. The Philippine government may gain insights into the appropriate steps and measures to implement its smart city initiatives by reviewing the experiences of international implementers. There should be an in-depth review of the pathways taken by other successful cities; however, the lack of empirical studies on the impact of smart city initiatives on individual cities is an obstacle. Nevertheless, a review of the limited research has been conducted to unravel potential pathways taken to attain smart city development.

A holistic approach is one pathway to consider. As Woetzel et al. (2018) pointed out, the positive consequences of initiatives can multiply when typical infrastructure systems and complementary policies accompany highly technological tools. Platforms should be supported by the domestic administrative and political leadership and institutionalized in local policies (see Noori et al. 2020). The holistic approach ensures that other government efforts complement smart city initiatives.

Improving data sharing is also a notable pathway. The importance of implementing an open data policy is reflected by the following PNS ISO 37122:2020 smart city indicators: (1) percentage of service contracts on the provision of city services with policy on open data and (2) yearly online visits to municipal open data platform for each population size of 100,000 (see BPS 2020). In open data-related initiatives, the public is given the opportunity to take part in smart city building through the use of available data.

The value of involving constituents in smart city development has also been recognized in various cases. Noori et al.'s (2020) research on Masdar City, Barcelona Smart City, Amsterdam Smart City, and Smart Dubai noted that some of these cases' initial projects have cultivated an innovative environment and included steps to involve constituents and ensure their gains. Meanwhile, Kubina et al. (2021), who looked at smart city cases in Europe and North America, maintained that the latter's success in models and standards is greatly due to its bottom-up approach. Other aspiring smart cities can similarly give recognition to their constituents' role in smart city development.

Applications to improve public services should be designed for public use. Woetzel et al. (2018) even regard applications and public usage as the second and third layers, respectively, on top of the technological base layer to operationalize smart cities. Furthermore, creating applications for public usage is a necessary pathway to becoming smart cities, given the targeted outcome of high quality of life.

Greenfield, brownfield, and pilot projects have been implemented by some aspiring smart cities. Greenfield projects aim to construct smart cities from scratch, and they are not built within established cities to avoid getting caught up in previously generated urban planning errors (Woetzel et al. 2018). Meanwhile, some brownfield projects are located in formerly developed plots (McNulty n.d.).

Regardless of where smart city initiatives are implemented, pilot projects should be carried out initially, especially because there is not much evidence on the impacts of such initiatives. There are pilot projects that have served as lighthouse projects. Noori et al. (2020) reported that some LGUs have honed lighthouse projects to reflect their brand, gain investments, and pave roads to smart city development. They added that data-driven experiments and living labs have been supported by collaborations among stakeholders (e.g., government, constituents, academe, industry). Aspiring smart cities may choose to implement projects suitable to their respective contexts.

The cases of Zaragoza, Abu Dhabi, and Busan

International cities of Zaragoza (Spain), Abu Dhabi (United Arab Emirates [UAE]), and Busan (South Korea) were selected from the Smart City Index to learn from their smart city journeys.[3] From 2019 to 2021, these three cities ranked higher than the City of Manila, the only Philippine city in the index. These cities have also consistently improved their rankings throughout the period, an achievement not attained by Manila (Table 1). The higher ranking and consistent performance of Zaragoza, Abu Dhabi, and Busan from 2019 to 2021 relative to Manila reflect the potential of the city cases to provide insights on options that LGUs can consider in moving closer to becoming smart cities. The Zaragoza, Abu Dhabi, and Busan cases have similarities and differences in the elements they employ in their smart city initiatives. This section relays insights on these cases in terms of enablers, pathways, and extent of smart city development based on available online resources. The aim is to provide an idea of the possible way forward for Philippine LGUs in their smart city development journeys.

[3] The Smart City Index was used as a reference in selecting international cities whose experiences are highlighted in this research. The smart city definition used in the index has similar themes with the working definition. According to Professor Arturo Bris of the Institute for Management Development (IMD) World Competitiveness Center, Professor Cheong Koon Hean of the Lee Kuan Yew Centre for Innovative Cities, and Bruno Lanvin of the IMD Smart City Observatory, a "smart city" in the context of the Smart City Index is "an urban setting that applies technology to enhance the benefits and diminish the shortcomings of urbanization for its citizens" (IMD and SUTD 2021, p.3). For the index, 120 residents were surveyed on issues relevant to structural and technological pillars in 5 key areas: (1) governance, (2) opportunities, (3) activities, (4) mobility, and (5) health and safety. Ratings for the Smart City Index are based on perception scores relative to the peers of a city within respective groups created based on United Nations Development Index scores. Smart City Index 2021, in particular, ranks 118 cities based on weighted perception scores from the last 3 years of the survey (IMD and SUTD 2021).

Table 1. Smart City Index rankings (2019–2021)

City	2019	2020	2021
Zaragoza	49	48	15
Abu Dhabi	56	42	28
Busan	50	46	37
Manila	94	104	102

Source: IMD and SUTD (2019, 2020, 2021)

Enablers

Having a vision is recognized as an enabler to the smart city development of Zaragoza. When the city established the vision for a knowledge-based society and digital district in the early 2000s, it started implementing smart city initiatives (Glasco 2018). According to Former Zaragoza Mayor Juan Alberto Belloch Julbe, technological innovation was promoted as the key to developing the economy, entrepreneurship, and municipal administration (Zaragoza Ayuntamiento n.d.). He added that Zaragoza's achievements include enhancing telecommunication networks and developing electronic administration and open data policy (Zaragoza Ayuntamiento n.d.). Thus, having a vision can clarify the targets of smart city initiatives to be implemented.

Stakeholder engagement is also seen as an enabler of smart city development. Abu Dhabi has collaborated with Singapore to get ideas from some Singaporean companies on how to solve some smart city challenges (Geronimo 2021). In addition, Abu Dhabi's Masdar City has signed an agreement with Huawei to use the company's IoT platform to develop applications to improve constituents' health-related decisionmaking (Noori et al. 2020). The project team of Masdar also engaged the British architectural company Foster + Partners to concretize the planned carbon-neutral neighborhood (Flint 2020). In the case of Zaragoza, the local government tapped the Zaragoza Knowledge City Foundation because of the latter's engagement with the financial sector, academe, and companies (Zaragoza Ayuntamiento n.d.). Furthermore, it worked with ABB for a cloud-based energy management platform (ABB 2019). Zaragoza has also engaged the Regional Government of Aragon to develop integrated information systems (Zaragoza Ayuntamiento n.d.).

In Busan's case, third-party developers were able to access municipal data, making way for public sector innovation (GSMA 2012). These examples reflect the importance these governments place on partnerships.

Private and public stakeholders have supported the financing of smart city initiatives. For instance, Zaragoza has developed the Crowdsourcing ZGZ so that urban planners can solicit funds from constituents for citizen-centric urban proposals while the city matches every Euro (Glasco 2018). The planners' proposals are approved for minimum viable product development once a threshold is reached (Glasco 2018). Zaragoza also had a public tender, giving a maintenance and energy efficiency contract to the Spanish company IMESA (ABB 2019). For Abu Dhabi's Masdar City, seed money was put in by the provincial capital (Flint 2020). Additionally, a public investment company facilitates financial transactions in smart city initiatives in the Masdar smart city project of Abu Dhabi. Mubadala Company, an investment firm from the regional government, provides and funds ICT infrastructures through outsourcing or its institutions (Noori et al. 2020). Hence, stakeholder engagement also paves the way to generate additional financial sources for smart city efforts.

Some cities, such as Abu Dhabi, have effectively branded themselves as smart city promoters. Noori et al. (2020) noted that Abu Dhabi likes to brand itself (e.g., by holding the Sustainability Week, whose participants include experts, youth, and policymakers) to increase investments and stretch its smart city development path. Abu Dhabi's Masdar City was converted into a smart city project from an eco-centered one when smart city as a competitive urban policy became a trend (Noori et al. 2020). However, some activities in relation to the development of Masdar City have fallen short of expectations. Noori et al. (2020) mentioned that the Mubadala Company initially relayed that a certain amount of funds would be set aside for Abu Dhabi's Masdar project, but a portion of the budget went to other projects. Regardless of the potential pitfalls, branding should still be considered an enabler because of its ability to attract investments.

Data protection is important in smart city development. Some cities have implemented relevant initiatives and policies aside from existing institutionalized national laws on data security in their

respective countries. Spain issued the Organic Law 3/2018 on the Protection of Personal Data and Guarantee of Digital Rights, requiring the appointment of a data protection officer within some entities and mandating the Agencia Española de Protección de Datos as the central regulatory authority (Lopez and Lapetra 2021). The importance Zaragoza places on data protection is evident in the webpage it allots to enumerating the areas and activities in which data are being collected from constituents and the corresponding manner in which the data are handled, including the duration in which the data will be kept (see Ayuntamiento de Zaragoza 2021). Meanwhile, the UAE does not have a comprehensive data protection law, but it does have laws related to privacy, like the ICT Health Law, whose provisions include the exclusive processing and management of health service-related data within the UAE (DLA Piper 2021). South Korea also has the Personal Information Protection Act 2011, regarded as one of the strictest data protection laws worldwide and has provisions on sanctions and a requirement of getting consent for some cases of data collection (Kwang and Minchae 2021). The South Korean law was considered in formulating Busan Metropolitan City's guidelines on personal information processing and handling (Busan Metropolitan City n.d.-a). The guidelines have provisions on the assignment of a chief privacy officer, duration of data retention, data destruction, and subject rights (Busan Metropolitan City n.d.-a). Based on these cases, data protection policies at the local level are worthy of being considered enablers of smart city development.

Pathways

The example cities value research and development with various stakeholders. For instance, research and development in Abu Dhabi's Masdar are supported by the Masdar Institute of Science and Technology, which partnered with the Massachusetts Institute of Technology and was eventually merged with Khalifa University (Noori et al. 2020). Masdar also has the Honeywell Masdar Innovation Center to generate innovative smart applications (Noori et al. 2020). Meanwhile, Zaragoza has established the Etopia Center of Arts and Technology, an innovation hub for entrepreneurs, technologists, and artists; Open Urban Lab, a research and development center promoting

co-creation; business incubators; and 100ideasZGZ, an innovation and civic ecosystem enabling citizen participation in the city's development (Glasco 2018). It has also collaborated with the University of Zaragoza in its smart city development agenda (Zaragoza Ayuntamiento n.d.). Building partnerships with the academe and creating innovation hubs are pathways taken by some international cities.

Aside from the typical brownfield projects, the cities have also implemented greenfield and pilot projects. Abu Dhabi's Masdar City, an investment zone and live-work community completely run by renewable energy, is an example of a greenfield project (Woetzel et al. 2018). Some of Abu Dhabi's initiatives include a driverless electric vehicle in Masdar City (Flint 2020). Meanwhile, Zaragoza has worked on the Valdespartera, a community with a centralized control and monitoring system facilitating decisionmaking through real-time data and remote equipment management (AVEVA 2020). Meanwhile, an example of a pilot project is the Busan Eco Delta City, developed to serve as a testbed for South Korea's adoption of various technologies and cultivation of an innovation ecosystem (Busan Metropolitan City n.d.-b). Lee (2020) noted that aspiring residents were encouraged to apply: 18 households would be selected among the applicants, while 36 would be drawn through a lottery by the Ministry of Land, Infrastructure and Transport, and Korea Water Resources. The author added that they would undergo a training program for one year before their move and that the initiatives include robots that collect waste, smart wearable bands monitoring residents' health and workout plans, and smart homes and unmanned stores. There would be two model units available that visitors can view (Lee 2020). Meanwhile, Abu Dhabi, in collaboration with Technology Strategies Middle East, deployed the Zayed Smart City project in the Corniche area, wherein Cumulocity IoT was utilized for the following use cases: swimming pool monitoring, water storage tank monitoring, waste management, smart parking, street lighting, palm tree weevil detection, water metering, structural health monitoring, asset tracking and logistics monitoring, and air quality monitoring (SmartCitiesWorld News Team 2018). Aspiring smart cities can select the types of projects suitable to their contexts.

Inclusivity is also targeted in some smart city initiatives. Busan has been developing barrier-free spaces for people with disabilities by

setting up digital kiosks at its biggest subway and train station. The kiosks interpret sign languages and relay routes customized for the user's disability (Park 2021). Busan's example sets a reminder that a smart city should cater to all constituents.

The development of applications and platforms has also been observed. Abu Dhabi has rolled out a smart cities virtualization application, enabling it to monitor whether street lighting and public transport are operating well (Spencer 2020). Additionally, Abu Dhabi partnered with Huawei to develop applications to enhance sustainability, productivity, and health to improve the decisionmaking skills of constituents (Noori et al. 2020). For Zaragoza's Valdespartera, a common data capture infrastructure was set up, sending information to the Sustainable Urban Centre, a unified control center to facilitate monitoring of compliance with environmental requirements (AVEVA 2020). It also has the System Platform acting as an industrial operating system that enables data connectivity, security, communication, deployment, and configuration through an integrated single software development environment (AVEVA 2020). Valdespartera's industrial systems are shown on desktops and video walls to allow remote supervision of operations (AVEVA 2020). Aspiring smart cities can develop various applications and platforms to realize targeted outcomes.

Extent

The reviewed literature on Zaragoza, Abu Dhabi, and Busan show a mix of smart city initiatives in the infrastructure and data phases. Specifically for Zaragoza, many initiatives are in the infrastructure and data phases. Initiatives within the infrastructure phase involve telecommunication networks and Valdespartera's desktops and video walls. Zaragoza's initiatives in the data phase include integrated information systems, a webpage relaying data collection and management details, and Valdespartera's common data capture infrastructure and system platform. Service phase initiatives of Zaragoza include the cloud-based energy management platform and centralized control and monitoring system. For Abu Dhabi, most initiatives are already in the service phase. These involve the Masdar Innovation Center and applications that enhance constituents' decisionmaking. Some initiatives belong to

the infrastructure phase, including Masdar's use of renewable energy to run the community and the IoT platform supporting application development. Meanwhile, several initiatives of Busan are in the service phase. Examples include Busan Eco Delta City's robot-collecting waste, smart wearable bands for health management, and digital kiosks for persons with disabilities. Busan also has initiatives in the data phase, such as the third-party developers' open access to municipal data and Busan Metropolitan City's personal information process and handling guidelines. Although the information in the reviewed literature is limited, Zaragoza's apparent initiatives in all three phases could have influenced its higher ranking in the Smart City Index 2021 compared with the other cities. Among the reviewed literature, there is a lack of information on the initiatives of Abu Dhabi in the data phase and Busan in the infrastructure phase. Additionally, Zaragoza has been able to relay its outputs comprehensively. In some of its strategic plans for smart city development, Zaragoza was able to specify its accomplished smart city initiatives (Zaragoza Ayuntamiento n.d.). Zaragoza's extensive initiatives, backed up by documentation, make it one of the international cities to look out for.

Methodology

A desk review of smart city efforts in some Philippine cities was conducted. This was complemented by interviews with LGUs from selected cities in the country and other stakeholders, including national government agencies (NGAs), businesses, and development organizations. Responses of LGUs are assessed relative to the views of other stakeholders and the contents of shared documents and online references.

Table 2 presents the profiles of selected cities for this study. Before interviews with LGUs, a desk review was conducted to initially identify cities with high implementation levels. Cities with high implementation levels are regarded as already implementing numerous smart city initiatives. Cities initially identified to have high implementation levels, as well as those that did not appear to reach the same levels based on the desk review, were included in the selection.

Two of the cities selected (i.e., Mandaue and Malabon) are highly urbanized (HUCs). Mandaue and Malabon are in the First Income Class and have population sizes of 364,116 and 380,522, respectively. Meanwhile, the cities of San Fernando in Pampanga and Tagum in Davao del Norte are also in the First Income Class but are non-HUCs (i.e., with population sizes of 354,666 and 296,202, respectively). Non-HUCs in the Third Income Class were also selected (Cauayan in Isabela and Tuguegarao in Cagayan), with population sizes of 143,403 and 166,334, respectively.

Table 2. Profiles of selected cities in the Philippines

City	HUC	Income Class	Population
Mandaue City	Yes	1st	364,116
Malabon City	Yes	1st	380,522
San Fernando City	No	1st	354,666
Tagum City	No	1st	296,202
Cauayan City	No	3rd	143,403
Tuguegarao City	No	3rd	166,334

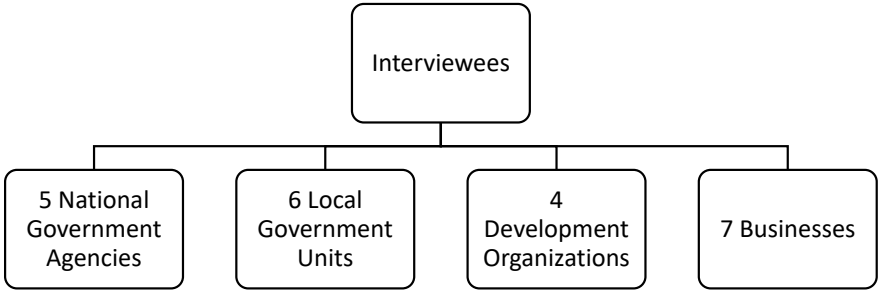
HUC = highly urbanized city; LGU = local government unit; PSA = Philippine Statistics Authority
Notes:
(1) The categorization of LGUs as HUC is as of 2020.
(2) The population is based on the 2020 Census of the PSA.
(3) Cities in gray rows have a high level of implementation based on desk reviews conducted before interviews.
Sources: PSA (2021a) for LGU categorization as HUC; PSA (2021b–h) for income class and population figures

LGUs in the selected cities were interviewed. Officials interviewed for each chosen site vary depending on availability and point persons identified through the snowball sampling method. The snowball sampling method was adopted because LGUs are expected to have different offices and policy implementation approaches. The set of interviewees per selected site may include the mayor's office,

Sangguniang Panlungsod (city council), and other officials with potential involvement in implementing smart city initiatives (e.g., City Planning and Development Department, Management Information System Section). Topics discussed include the following: (1) definition of "smart city", (2) smart city development phase in which LGU implements smart city initiatives, (3) enablers of smart city development, (4) addressing financial requirements for smart city development, (5) expected influence of Mandanas-Garcia Supreme Court Ruling on financing, (5) challenges and potential solutions, and (6) implementation pathways to support smart city development. In addition to analyzing the interviews with LGUs, the contents of relevant LGU documents and online references were reviewed.

Some private sector stakeholders involved in smart city initiatives were also interviewed (Figure 5), including 4 development organizations and 7 businesses. Interviewed development organizations are supporting smart city development's infrastructure and data phase through networking, financing, and providing service and technical support. Those involved in the infrastructure phase help capacitate LGUs and even link them to businesses that can provide infrastructure technology involving focus areas of quality environment. In contrast, those in the data phase provide data-relevant technology involving safety, security, and built infrastructure.

Figure 5. Interviewees



Source: Authors' illustration

In the mean time, interviewed businesses are involved in the infrastructure and service phases. Their activities include providing service, technical support, networking, financing, consultancy, and manufacturing. Those engaged in the infrastructure phase donate and provide infrastructure technology related to focus areas of built infrastructure, quality environment, and industry and innovation. In contrast, those involved in the service phase provide technology that focuses on safety and security. Topics discussed with interviewed private stakeholders include their definition of "smart city", smart city initiatives they support, reasons for engaging with LGUs on smart city initiatives, support for smart city initiatives, challenges encountered in engagement with LGUs, implementation pathways government can take to gain more private sector participation in smart city initiatives, and lessons learned from supporting the development and implementation of smart city initiatives.

Meanwhile, some NGAs with potential involvement in smart city development were also interviewed (Figure 5). Topics discussed with interviewed NGAs include their definition of "smart city", smart city development phase they are involved in, enablers of smart city development, challenges to smart city development, and implementation pathways to support smart city development. Interviewed NGAs include the Department of the Interior and Local Government (DILG), DICT, DOST-PCIEERD, Public-Private Partnership (PPP) Center, and National Privacy Commission (NPC). The research includes NGAs because their mandates reflect their potential influence on building smart cities. For instance, the DILG (2013) is tasked with providing support in supervision over local governments. Meanwhile, the DICT (n.d.-a) is in charge of planning, promoting, and developing the national ICT agenda according to Republic Act (RA) 10844. The DOST-PCIEERD (n.d.-b) is the main agency that creates plans, policies, and programs and implements strategies in energy, industry, and emerging technology sectors via science and technology activities. In addition, the PPP Center (n.d.-a) facilitates the implementation of PPP projects and programs. Meanwhile, the NPC (n.d.) is mandated to carry out RA 10173 or the Data Privacy Act of 2012. The discussion provides insights into the relevance of the interviewed NGAs in smart city development.

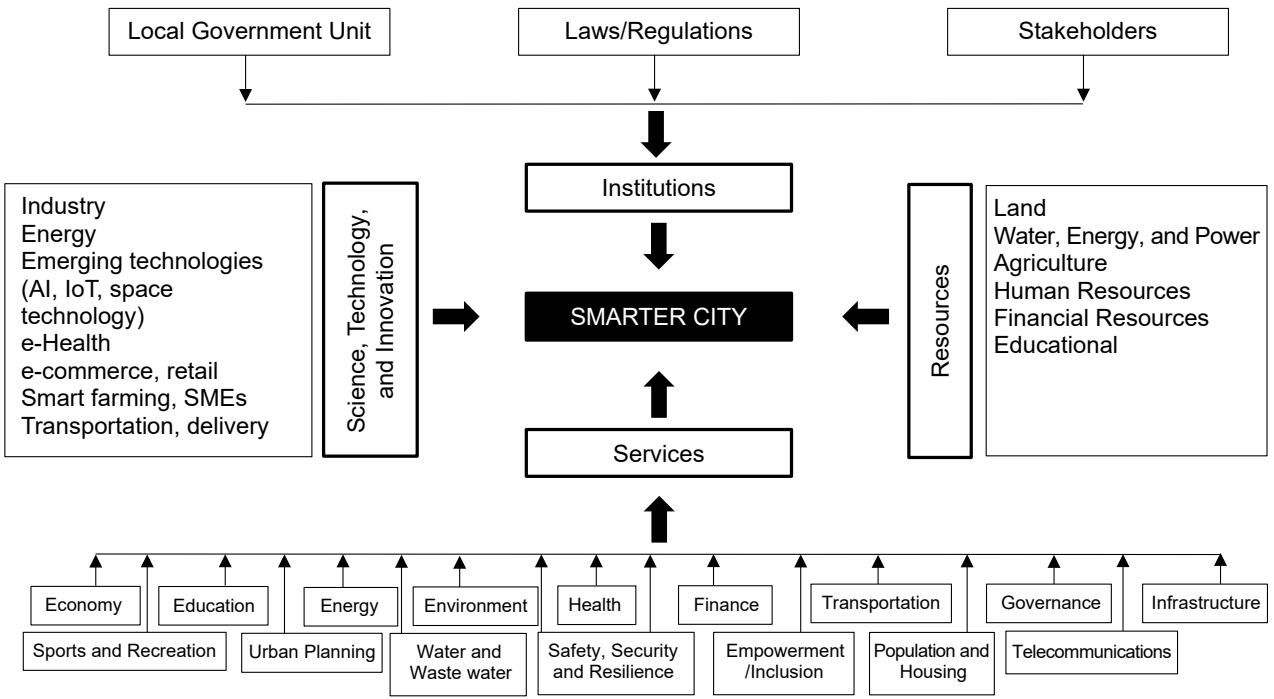
Findings based on interviews and contents of shared documents and online references are used to assess the readiness of Philippine cities for smart city development. They address the policy questions on drivers, the extent of smart city development in the cities whose LGUs were interviewed, and the pathways the Philippine government can take to facilitate the development.

Relevant Initiatives of NGAs in the Philippines

The Philippine government has programs and policies that can support smart city development in the country. Their programs can be integrated with the infrastructure, data, and service phases of smart city development and in the preparation of LGUs in implementing relevant initiatives. This section shall present NGA programs/activities based on the smart city development phase they are most aligned with. Such a presentation is expected to help LGUs gain insights on which agencies they can approach and which programs/activities they can tap depending on initiatives they plan to implement or are already implementing.

The DOST-PCIEERD (n.d.-a) has developed a framework for smart sustainable communities and cities (Figure 6). It emphasizes that a smarter city has the following goals: (1) economic development, (2) quality of life, (3) public safety, (4) mobility, (5) health and wellness, (6) sustainability, and (7) government efficiency. DOST's smarter city approach is targeted to attain the following: (1) collaboration among stakeholders, (2) transferability in technological approaches and tools, (3) integration of technologies of public organizations and local governments, (4) openness in data, and (5) shared vision/human centric. The roles of DOST in developing smart sustainable cities and communities have been identified as advancing data use and sharing, encouraging partnerships, and financing research. Hence, it promotes the conduct of a gap assessment and priority setting. The following are the themes for smart city indicators for sustainable development of communities: (1) economic opportunity; (2) education; (3) environmental quality; (4) waste and wastewater; (5) energy; (6) finance; (7) governance; (8) health and living recreation; (9) safety, security, and resilience; (10) infrastructure; (11) transportation and mobility; (12) urban planning; and (13) empowerment and inclusion.

Figure 6. DOST framework for smart sustainable communities and cities



DOST = Department of Science and Technology; AI = artificial intelligence; IoT = Internet of Things; SMEs = small and medium enterprises
Source: DOST-PCIEERD (n.d.-a)

Although this framework helps guide smart city initiatives, some aspects can still be improved. In particular, the principle of accountability is not emphasized in the framework. A smart city not only collects data from various stakeholders but also provides data to stakeholders who can make use of the data to contribute to smart city development. If constituents know the capability of a smart city, they are also likely to demand access to data, increasing public accountability. Another opportunity for improvement is in promoting the framework, as LGUs' use of the framework in adopting smart city initiatives has not been evident, suggesting they are unaware of its existence.

Activities of the PPP Center can also support smart city development. Given its expertise in public-private partnerships, the center can potentially guide LGUs with smart city PPP projects, which are common in international cities. The PPP Center has reliable recording and data-sharing practices. The agency maintains an online record of local PPP projects, detailing information such as brief project description, project cost, and private proponent (see PPP Center n.d.-b). However, identifying which projects are smart city initiatives is not possible using the center's records. Nevertheless, it is notable that the PPP Center's basis for prioritizing projects is enclosed in the Public-Private Partnership Governing Board Guidelines on the Identification, Selection, and Prioritization of PPP Projects (see PPP Center n.d.-c). Using a multicriteria analysis, the PPP Center considers the following elements in evaluating projects: institutional readiness of the implementing agency, appropriate risk sharing, manageable life cycle costs, and market acceptability (see PPP Center n.d.-c). Furthermore, PPP Center places some projects under the Project Development and Monitoring Facility, a revolving fund for preinvestment activities, such as feasibility studies (Camus 2021). Although the center does not offer a specialized track for smart city initiatives under the PPP mode, it can still support aspiring smart cities in developing their projects.

Infrastructure phase

Within the infrastructure phase, the DOST has the potential to support smart city initiatives. The DOST-PCIEERD has been accepting proposals, such as those under its Convergence of Emerging

Technologies/Sectors Towards Industry 4.0 and Smarter Cities and Communities in the Philippines projects (DOST-PCIEERD n.d.-c). These projects include sensors and actuators for intelligent factories, 5G product and application development, space technology applications in public services, and sustainability through innovation in cities (DOST-PCIEERD n.d.-c). The DOST also has the Collaborative Research and Development to Leverage Philippine Economy (CRADLE) program, wherein Philippine businesses collaborate with research and development institutions and/or the academe for product and operations development (DOST 2021). Under the CRADLE program, businesses must commit to adopting the technology and shell in at least 20 percent of the cost (DOST 2021). Although there is a lack of studies subjecting the mentioned programs to assessments, the DOST initiatives can help strengthen the foundations of smart city development because of the technologies that can be developed through these projects or programs.

The DICT can also help in the infrastructure phase through the National Broadband Program (NBP). The NBP aims to provide consistent broadband capacity in the Philippines while cutting internet subscription costs (DICT 2020a). Government agencies' access to relatively affordable internet service would be at PHP 50 per megabit per second (Mbps) of bandwidth each month (DICT 2020a). Priority is given to inaccessible and remote areas regarded as unprofitable by the private sector (DICT 2020a). Given connectivity's importance in deploying and using smart city tools, the DICT's success in implementing the NBP will support smart city development. However, the NBP has encountered issues, including delays in the rollout, said to be caused mainly by civil work roadblocks (Romero 2022). Additionally, in 2020, the program reportedly had problems getting funding for the succeeding years (Camus 2020). Former Senator Panfilo Lacson also observed that the DICT was not getting sufficient funding despite the savings that could be generated through the NBP (Ping Lacson 2020). Hence, the financial issues related to the NBP must be addressed for the program to facilitate smart city development.

Another program that can potentially support smart city initiatives within the infrastructure phase is the DICT's Free Wi-Fi for All project. The DICT has been implementing the Free Wi-Fi for All program to increase access of Filipinos to the internet (DICT n.d.-b). The project

is supported by RA 10929 or the Free Internet Access in Public Places Act, which provides for free internet service in public areas (e.g., public transport terminals, public hospitals) across the country, with the DICT as the lead implementing agency. The law also mandates the agency to ensure that each user has a minimum internet speed of 2 Mbps or as prescribed by the NBP, whichever is higher. However, the Free Wi-Fi for All has been criticized for its poor implementation (Marcelo 2022). For instance, only 11,618 sites were built out of the targeted 34,442 free Wi-Fi sites by the end of 2021, according to the accomplishment report of the DICT Program Management Office, as noted by the Commission on Audit (COA) (Marcelo 2022). The COA also observed that out of the reported sites built, only 6,658 were proven to exist as of April 13, 2022 (Marcelo 2022). According to the DICT Program Management Office, the low accomplishment was caused by technical issues with the project's network architecture, problems getting permits and memorandums of agreement, and procurement delays (Marcelo 2022). The DICT's Free Wi-Fi for All can address the lack of connectivity among constituents, but the program's challenges still need to be resolved.

Countryside development has also been a target of the DICT through its Digital Cities Program. The DICT has launched the Digital Cities Program in collaboration with the Leechiu Property Consultants and Information Technology and Business Process Association of the Philippines (IBPAP) to support countryside digital jobs growth (DICT 2021a). Selected cities for the program are tagged as having a high potential for transformation into digital cities and are expected to have an increase in domestically available information technology and business process management (IT-BPM) jobs (Dela Cruz 2020). Interventions under the program include stakeholders and design thinking workshops and strategic planning to support countryside cities in developing 5-year ICT industry roadmaps (DICT 2021a). As of July 2021, around 9 cities successfully completed their 5-year roadmaps (Abadilla 2021). According to Undersecretary Emmanuel Rey Caintic, program interventions would include connectivity enhancement support from the DICT (Dela Cruz 2020). The Digital Cities Program, with its comprehensive approach to countryside development, can help build smart cities.

Data phase

A secure data flow has been made possible within the data phase by implementing RA 10173 or the Data Privacy Act of 2012. This law sets out the policy of the state, ensuring free-flowing information for development while safeguarding privacy. It also has provisions on data subjects' rights and penalties for unauthorized personal information processing. RA 10173 established the NPC, whose mandates include engaging with government agencies and the private sector to design policies and plans to improve personal information security and monitor compliance with data protection standards. The NPC also has statistics on breach notifications. Through RA 10173, the NPC has the capacity to ensure data protection; however, issues have been raised regarding the law's implementation. In 2020, it was reported that there was a lack of penalties imposed in the form of imprisonment or fines on violators since the NPC was established (Damazo-Santos 2020).

Emphasis on data sharing accompanies the policy to protect data. Hence, the government has implemented the Freedom of Information (FOI) Program under Executive Order (EO) 2 (s. 2016). This policy provides that each Filipino should have access to public and official records; information; government research data; and papers and documents on official acts, decisions, or transactions. The Presidential Communications Operations Office (PCOO) serves as the coordinator for the FOI Program (FOI Philippines n.d.). Under the program, Filipino citizens may request information on government operations and transactions as long as they do not pertain to privacy and national security matters. The FOI Program offers an open data mechanism consistent with the smart city concept. However, its implementation has been criticized. For instance, the Philippine Center for Investigative Journalism reported the following issues: (1) unsatisfactory results that were supposed to address requests, (2) delayed feedback from government offices, and (3) numerous denied requests (Perez 2020).

Various platforms can be tapped to gain access to data. The platform OpenStat, managed by the PSA, increases access to PSA-gathered data (PSA 2021i). The datasets are divided into the following domains: (1) environment and multidomain statistics, (2) economic statistics, and (3) demographic and social statistics (PSA 2021j). The DICT (n.d.-c)

also has a platform called Open Data Philippines, which aims to increase access to datasets from government agencies. It divides datasets according to the following sectors: (1) agriculture and food security; (2) arts, culture, and heritage; (3) banking and finance; (4) business and entrepreneurship; (5) defense and national security; (6) education and training; (7) energy; (8) environment and natural resources; (9) foreign affairs; (10) health; (11) housing and urban development; (12) labor and employment; (13) law enforcement and justice; (14) local government; (15) national governance; (16) public infrastructure; (17) science and technology; (18) special concerns; (19) transportation; and (20) travel and tourism (DICT n.d.-d). Cited issues on the Open Data Philippines include the lack of information management capacity, digital divide, and lack of appreciation from some government agencies (Pacis 2017). The available platforms are expected to support the FOI policy of the government.

Capacity building to enhance data management is also being supported by the government. The DOST-PCIEERD, in collaboration with the Development Academy of the Philippines (DAP) and PCOO, has been implementing the Smarter Philippines through Data Analytics Research and Development, Training and Adoption (SPARTA) to train 30,000 Filipinos on data management (DOST-PCIEERD 2020a). The DOST-PCIEERD has also been implementing the Good Governance through Data Science and Decision Support System (GODDESS) Program to fund data science research and development projects that could enhance the operations of LGUs and NGAs (DOST-PCIEERD 2021). The capacity-building programs of the DOST-PCIEERD can ensure the availability of human capital to support smart city building.

Service phase

RA 11032, or the Ease of Doing Business and Efficient Government Service Delivery Act of 2018 (Anti-Red Tape Act [ARTA]), supports the service phase of smart city development. ARTA mandates NGAs and LGUs to reengineer their respective procedures and systems in accordance with its provisions, including a zero-contact policy. In consultation with the NPC, the DICT is likewise mandated to develop the Central Business Portal (CBP), a central application system for business-related clearances,

permits, licenses, or authorizations issued by LGUs. Meanwhile, Joint Memorandum Circular 1 (s. 2016) of the DILG, Department of Trade and Industry, and DICT encourages LGUs to computerize and automate their business permit process and use electronic and online mechanisms for efficient business processing. The policies can encourage LGUs to implement smart city initiatives because of their potential to ensure ease of doing business and efficient government service delivery. Medina-Guce et al.'s (2019) assessment of the implementation of the ARTA shows a positive impact of implementing ARTA on government efficiency and client satisfaction in frontline service delivery. They further noted that "success is most observed when (a) there are agency-level initiatives that translate the ARTA standards into policies and programs that promote efficiency among respective agencies and offices, and (b) there is significant leadership and management support for ARTA-related programs that translate into prioritization of outcomes achievement and technology and resource allocation into the programs" (pp. 6–7).

Overview of Smart City Initiatives in the Philippines

Many cities in the Philippines have been using smart city tools, and some are in the process of planning and/or establishing agreements with stakeholders. Smart city development phases to which the initiatives belong have been highlighted in this section to provide insights into the development within the specified areas. Initiatives are also presented in terms of their alignment with the working definition. However, it must be noted that the reviews of the smart initiatives in this section are mainly based on online references.

Metro Manila

Infrastructure phase

Aspiring smart cities in Metro Manila place a high value on connectivity. Infrastructures, such as the internet, have been set up to process and communicate data and information by, from, and to the people and institutions to attain a high quality of life. According to Mayor Mar-Len Abigail Binay, 25 barangays in Makati City are equipped with a fiber

optic cable loop, enabling residents to access free Wi-Fi service during particular periods of the day (*Manila Bulletin* 2020). The project on the fiber optic loop was a collaboration with Neo Tech Asia Distribution Inc. and Converge Information and Communications Technology Solutions Inc. (Mocon-Ciriaco 2017). In addition, Makati City has also been working on improving cellular bandwidths through mobile signal boosters (Marasigan 2019). Free Wi-Fi is provided to constituents in particular areas of San Juan City, made possible by the Google Station deployed by Smart Communications Inc. (L.S. Marasigan 2019). Meanwhile, San Juan City partnered with Globe Telecom to create Wi-Fi zones in some public areas and barangays (Marquez 2019). It also established free Wi-Fi, in cooperation with the DICT, in specific areas of the city (Umali 2019). Additionally, Smart Communications has been providing free Wi-Fi to residents of Las Piñas, Mandaluyong, Malabon, Parañaque, and San Juan through their Smart Barangay Connect Program, aided by PLDT's fiber infrastructure (see Barrientos 2021 and Mercurio 2021). Meanwhile, Pasig City teamed up with Globe Telecom to deploy its KonekTayo WiFi buses, which serve as hotspots to particular areas at designated periods of the day at a price (Aglipay 2020). The experiences in increasing constituents' access to the internet reflect the potential role of other stakeholders even in the early phases of building a smart city.

Initiatives involving smart city-related infrastructures in Metro Manila include deploying tools that sense, monitor, process, translate, and communicate quality environment and mobility data and information by, from, and to the people and institutions for a sustainable environment and high-quality life. This was demonstrated in Manila City's engagement with Rotary International, United States Agency for International Development, community groups, and government agencies for the Sta. Ana Public Market Wastewater Treatment Plant, which facilitated maintenance and operation, resulting in reduced wastewater treatment costs (Gambrill n.d.). Meanwhile, Pasig City has a project on solar-powered citywide mass alert sirens (The Good News Pilipinas Team 2018). The City of Pasig was also a collaborator in the Philippine Postal Corporation's (PHLPost) "Green Delivery" electric vehicles, which conduct deliveries (Quadra-Balibay 2020). Pasig City has also collaborated with the Ateneo de Manila University (ADMU)

to access green technologies and infrared radiation cameras on drones (Coastal Cities at Risk in the Philippines 2019). Meanwhile, the New Manila Bay-City of Pearl, a smart city project designed by Hong Kong architectural company Ho & Partners Architects Engineers & Development Consultants Limited, is envisioned to use solar and tidal energy and to have a driverless railway system, water taxis, and a smart grid powered by artificial intelligence to monitor energy production, consumption, and transportation (Seow 2017). On the other hand, Valenzuela City established a solar power farm (Olandres 2015), while Makati City has been eyeing to shift to electric-powered/hybrid vehicles (Marasigan 2019). The discussions in this section show that the attainment of a quality environment is on the agenda of some Metro Manila LGUs.

Data phase

Some LGUs in Metro Manila have been attempting to increase the ability of their respective constituents to communicate with them. This has been done by deploying various platforms that process, translate, and communicate civic and social and safety and security data, information, and knowledge from the people to attain a high quality of life. For instance, the Makatizen App enables constituents to be informed and relays issues such as emergencies and crimes (Lalu 2019). Meanwhile, with the help of local tech company Senti AI and Google Philippines, Manila City established a Google Forms-powered complaints desk, in which constituents' complaints are submitted, collected, processed through natural language processing, and sent to appropriate departments (*Newsbytes.PH* 2020). Furthermore, Pasig City used a Seattle-based developers' online platform for an online survey, leveraging machine learning to analyze the respondents' approval or disapproval of LGU-formulated statements on open streets (Ranada 2020). LGUs' efforts to boost communication with constituents reflect their understanding of smart cities' people-centric concept.

Safety and security are the focus themes of some smart city initiatives in Metro Manila. The smart city tools sense, monitor, process, translate, and communicate safety and security data and information by, from, and to the people and institutions to attain a high quality of life.

For instance, smart city technologies were piloted in Caloocan City in collaboration with Iveda, whose technologies (e.g., facial recognition and license plate recognition) can trigger actions without physical human intervention (Smart Cities World Forums 2019). Meanwhile, Makati City has the Command Center Vans with telecommunication equipment connected to the mainframe of the LGU, enabling governance continuity even when disruptions occur due to disasters. The city also plans to allow the delivery of live images from the body cameras of law enforcers to the LGU's command centers (Marasigan 2019). Additionally, Makati City has installed closed-circuit television (CCTV) cameras as part of its disaster risk reduction and management (Cepeda 2020). Meanwhile, smart city initiatives of Pasig City include a computer-aided dispatch project where incident reports are sent in real time to emergency services, an emergency network global system for mobile communications (GSM) for emergency cellular calls and text messages during calamities, and a flood awareness simulation tool where scenarios and information about flood-prone areas can be generated (The Good News Pilipinas Team 2018). Meanwhile, Quezon City has an Emergency Operations Center, a monitoring system for issues related to emergencies and security (Koh 2017). In the City of Taguig, the Taguig Weather Monitoring System was set up to give real-time information and updates on phenomena such as disasters, storms, and weather conditions using cameras and analytics (Caliwan 2020). Furthermore, Mandaluyong City and PLDT deployed Smart SOS Dispatch solutions and CCTVs (Valencia 2018). Marikina City, meanwhile, plans to establish a camera surveillance system and a command center with access to a computer-aided dispatch system, as well as acquire digital radio handsets, internet protocol (IP) cameras, teleconference endpoint, one-key emergency button devices, and digital information display from China International Telecommunication Construction Corporation. This was according to the DILG, the city's partner in implementing the Safe Philippines Project (Arevalo and Santos 2019). Meanwhile, Manila City has planned to improve its command center by incorporating a cloud-based system (ASEAN 2018). In addition, Pasay City intends to have CCTVs in some areas of the city (Villanueva 2008). The cases discussed in this section show the importance LGUs in Metro place in safety and security.

Service phase

In some cities, some identity documents (IDs) and platforms are being used in government transactions. These IDs and platforms process, translate, and communicate civic and social-related data and information by, from, and to the people and institutions to attain a high quality of life and a competitive economy. Manila City has provided IDs to some constituents to allow cashless distributions and payments (PayMaya n.d.). Allowances and benefits can be stored via the IDs, which can then be used to buy from merchants and mobile Kadiwa shops, transfer money, purchase mobile phone loads, and pay bills (PayMaya n.d.). Meanwhile, Manila City's Go Manila Online Services processes licenses, permits, health certificates, birth certificates, and community tax certificates (City of Manila 2020). On the other hand, Makati City launched the Makatizen Universal Card System in 2017 with iBayad Online Ventures Inc. and G-xchange as partners (Mocon-Ciriaco 2017). It also partnered with Globe Telecom in providing Makatizen Cards to some constituents (*Manila Bulletin* 2020). The Makatizen Card is used to distribute financial assistance to constituents (Lucas 2020). Additionally, the ID is used in payments, money transfers, and receipt of stipends and salaries (Gonzales 2020). Furthermore, the Makatizen Card enables paperless government transactions and functions as an updated census, given the personal data stored in it (Marasigan 2019). Pasay City also introduced the Electronic Mamamayan ID, a city ID that can also be used in contact tracing, commerce, and as an e-wallet to distribute financial aid (Nazario 2021). It was also used to establish a cloud server-enabled citizen registration management system containing information and data of registered citizens (Nazario 2021). Other government agencies can access these data during emergency crises for more efficient responses (Nazario 2021). Thus, some LGUs in Metro Manila make government transactions easier through IDs and platforms.

Online and mobile payment platforms for constituents have also been deployed and used in some Metro Manila cities. In Caloocan City, payments of quarterly business tax and real property tax via mobile devices or computers can be made through the Link.BizPortal of the Land Bank of the Philippines (LANDBANK 2020). Navotas City has a similar engagement with LANDBANK through the Link.BizPortal, wherein it can monitor relevant collections each day in real time (LANDBANK 2021).

In collaboration with NeoConverge, the digital arm of Smart and PLDT, Makati City deployed the Makatizen App (*Manila Bulletin* 2020). The application, in conjunction with the Makatizen Card, has been used in receiving financial assistance from the LGU (Lucas 2020). Meanwhile, Manila and Parañaque partnered with Multisys Technologies Corporation for the Go Manila Online Services, which enable real property tax payments, and the Electronic and Online Payment Collection System of Parañaque to facilitate cashless, contactless, and paperless transactions with the LGU (see City of Manila 2020 and *Business World* 2021). Quezon City also enabled government-related payments through a mobile and online platform (Koh 2017). The City of San Juan has a mobile and web application, allowing the constituents to pay real property tax online and on mobile (City of San Juan Local Government System 2020). Additionally, Marikina City has engaged with Bayad Center to allow bills payment via modes that include smart city applications (*Inquirer* 2020). Lastly, Valenzuela City has an online application system to process business permit applications from filing to payment (Tuquero 2019). These platforms are expected to facilitate payment transactions.

Health and well-being are the focus of some smart city platforms in Metro Manila. These platforms sense, monitor, process, and communicate health and well-being data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life. Manila City has planned to create tutorial applications where teachers can guide their students in their lessons (ASEAN 2018). Taguig also launched the Taguig Online Resources and Community Hub (TORCH) to prepare its residents for the new normal (Nazario 2020). TORCH introduces teacher training, an online resource hub for seniors, an open campus for professionals, resources to help businesses adjust, and government information portals (Nazario 2020). Meanwhile, some LGUs have been deploying COVID-19-related platforms. For instance, all cities in Metro Manila have an online platform for COVID-19 vaccine registration (CNN PH 2021). Quezon City has launched new digital tools, such as the Tanod Kontra COVID (TKC) information system and the KyusiPass (QCPass), to enhance the efficiency of tracking and containing the virus (Junio 2021). In addition, Navotas City developed an online application to track the response of the LGU to the ongoing COVID-19

pandemic (e.g., notifying constituents of COVID-19 test results, deploying to or from isolation facilities) (David 2020a). Additionally, the Makatizen App allows constituents to make appointments at barangay health centers, determine how many patients are in line, and be notified when it is their turn to transact (Cepeda 2020). Hence, smart city platforms can help increase the constituents' quality of life.

Businesses can gain from smart city initiatives by adopting platforms that can sense, monitor, process, translate, and communicate industry and innovation data and information by, from, and to people and institutions to attain a competitive economy. As in previous examples, private sector companies have collaborated with LGUs to implement smart city initiatives, providing them with a potential source of additional income. They also benefit from the online platforms that facilitate government transactions and payment settlements. Aside from such gains, businesses have become direct beneficiaries of smart city projects. For instance, the City of Navotas partnered with Grab Philippines to onboard businesses and drivers on Grab-related applications (*Speed Magazine* 2020). Furthermore, Valenzuela City collaborated with Grab Philippines to create a mapping system using local data, increasing the efficiency and accuracy of deliveries through the Grab application (*Malaya* 2019). Given the potential advantages of smart city initiatives to businesses, companies should include collaborating with aspiring smart cities in their agenda.

Metro Clark

Infrastructure phase

Meanwhile, building connectivity infrastructure is high on the agenda of some aspiring smart cities in Metro Clark. These infrastructures help process and communicate data and information by, from, and to the people and institutions to attain a high quality of life. According to Gilbert David, assistant network administrator of Angeles City's Information and Communications Technology Division, internet connection and network equipment in the city hall have been enhanced to increase the efficiency of online payment, while networks of installed data cabinets were consolidated to build a centralized server (Carbungco 2020). Meanwhile, Mabalacat City engaged the DICT and

Metro Clark Information and Communications Technology to install free Wi-Fi in key areas, such as the city hall, through a project called "Pipol Konek" (Navales 2018). Additionally, San Fernando City tapped Smart Communications to provide free fiber-powered Wi-Fi through Google Station (Smart Communications 2019a). These examples showcase the value Metro Clark cities put on the internet as an important component of building smart cities.

Service phase

Platforms with civic and social focus are being promoted in some cities. These platforms process and translate data and information by, from, and to the people and institutions to attain a high quality of life. Angeles City has implemented online services for collecting real property taxes, issuing occupational and business permits, health, community tax, and birth certificates and licenses (City of Angeles 2020). The city has also established a system where constituents can make cashless payments in public transportation and markets (Gunio 2020). It also intends to deploy kiosks in each barangay for paying basic traffic fines and real property and business taxes (Gunio 2020). These platforms cater to constituents wanting faster payment options in their government transactions. San Fernando City has continuously boosted its online business permit application system since 2017 (Flora 2021). Likewise, it deployed electronic queuing systems in city government offices to centralize public transactions (Flora 2021). Aside from improving public services, these efforts to ease the process of doing business also contribute to bolstering economic development.

Safety, security, and health are key themes in some smart city initiatives under the service phase. These initiatives can help sense, monitor, process, translate, and communicate data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life. For instance, San Fernando City intends to equip its command and control center with light-emitting diode boards for traffic safety, cable for voice facilities for easy collaboration with other government offices, a computer-aided dispatch system, and a video management system (Tecson 2018). Meanwhile, Angeles City is eyeing to expand its Emergency Disaster Command Center (Gunio 2020).

Some other smart city initiatives of the city focus on health, such as implementing StaySafe.PH mobile application for COVID-19 contact tracing (Dharmaraj 2020a). Safety, security, and health are the focus areas of some Metro Clark LGUs in their smart city initiatives.

Metro Cebu

Data phase

Cebu City has been recognized for its smart city development initiatives in the data phase category. For instance, the Cebu Business Application and Online Analytics project was recognized at the 2018 Digital Cities Philippines Awards Night as a world-class ICT system (Dagooc 2018). Another is its GeoHazard Mapping Information System for better disaster preparedness and management (Dagooc 2018). These recognized efforts are in line with smart cities' function to sense, monitor, process, translate, and communicate safety and security and industry and innovation-related data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life, competitive economy, and sustainable environment.

Meanwhile, some smart city plans highlight visualization involving sensing, monitoring, processing, translating, and communicating data and information. For instance, Cebu City plans to leverage a centralized geographic information system (GIS) and develop 3D context models in implementing projects (Bhattacharya 2018). Such programs could pave the way for creating a digital twin.[4]

Service phase

Safety and security and quality environment are themes being exhibited by some smart city initiatives under the service phase in Metro Cebu. For example, Mandaue City installed a CCTV system and implemented the Guardian Emergency Response System, an application enabling a one-touch key to relay incidents and get assistance in times of emergency (*SunStar Cebu* 2019). Likewise, Cebu City intends to install

[4] There are various interpretations on the term "digital twin", but "it is generally believed that the 'Digital Twin' is a simulation process that makes full use of physical models, sensors, historical data of operation, etc. to integrate information of multi-discipline, multi-physical quantities, multi-scale, and multi-probability" (Deren et al. 2021, p.1).

higher-resolution CCTV cameras (ASEAN 2018). Meanwhile, Naga City promotes circular economy technology (see Neola 2021). These projects reflect the value these cities place on the smart city focus areas and the need to sense, process, translate, and communicate data and information from the people and institutions to achieve a high quality of life and a sustainable environment.

Metro Davao

Infrastructure phase

Some cities in Metro Davao have been laying the foundation for implementing smart city initiatives through infrastructures that can help in processing and communicating industry and innovation data and information by, from, and to the people and institutions to attain a high quality of life and competitive economy. For instance, Davao City has installed Wi-Fi in key areas, such as the local airport (*The Economist* 2017). The city is also connected through fiber optics deployed by telecommunication companies, including the PLDT (Llemit 2020). Meanwhile, the underground cabling project is a joint initiative of the Davao City LGU, Davao Light and Power Company (DLPC), and other utilities (Francisco 2018). The first phase, which covered the removal of underground cables along the downtown area surrounding LGU buildings, was completed in 2017 (Francisco 2018). According to a DLPC official, 6 circuit kilometers (km) of overhead lines, costing PHP 1 billion, will be installed as part of the project's second phase (Francisco 2018). In Tagum City, point-to-point internet towers have been deployed (Aglosolos n.d.). The City's Center of Justice Building also has the Technology for Education, Employment, Entrepreneurs, and Economic Development (Tech4ED), which is a facility providing access to ICT-enabled services and relevant content (see Tagum City Information Office 2018a). Launched in 2018, the project, a collaboration between DICT and Tagum City's Public Education and Employment Services Office, is envisioned to facilitate technology empowerment in entrepreneurship, employment, economic development, and education (see *BusinessWorld* 2018; Tagum City Information Office 2018a). These projects show the priority some Metro Davao cities place on increasing internet and technology access.

Some infrastructure-related initiatives by aspiring smart cities focus on mobility. For instance, the City of Davao has been working on the High-Priority Bus System, which will be complemented by an improved traffic signalization and management center (Burgos 2019). According to Department of Transportation (DOTr) Secretary Arthur Tugade, 626 km of the road network will be covered in the system (Dela Cruz 2021). The DOTr, Land Transportation Franchising and Regulatory Board, and Land Transportation Office are involved inthe capacity building for the planning, regulating, implementing, and monitoring (DOTr 2019). The project is financed by the Asian Development Bank, with GHD Pty Ltd. as a consultant (Davao City Government n.d.-a). The PHP 18.66 billion official development assistance for the project is allotted for public transport system improvement, program institutional capacity strengthening, and social development program (DOTr 2019). The National Economic and Development Authority-Investment Coordination Committee approved the project in 2019 (DOTr 2019). According to DOTr Secretary Tugade, the project will be completed in the third quarter of 2023 (Dela Cruz 2021).

Quality environment is also a focus of some initiatives involving infrastructure. These projects can process and translate quality environmental data and information to attain a sustainable environment. For example, the Davao City LGU uses a technology that converts used cooking oil to biodiesel fuel (Carillo 2017). The technology was acquired through a collaboration with the Japanese government, the Japan International Cooperation Agency (JICA), the Shinozaki Transport Warehouse Co. Ltd., and technology manufacturer Biomass Japan Inc. (Carillo 2017).

Service phase

Some Metro Davao cities value safety and security as reflected in their initiatives that sense, process, and communicate safety and security data and information by, from, and to the people and institutions to attain a high quality of life. For instance, Davao City LGU has the Public Safety and Security Command Center (PSSCC), which oversees safety and security-related activities (Ludher et al. 2018). It utilizes GIS-mapped data, a CCTV surveillance system, traffic cameras and

signalization systems, and Interpol's I-24/7 database (Ludher et al. 2018). The PSSCC has deployed 190 surveillance cameras (DAP 2020), likely to be linked to the city's centralized dashboard (*The Economist* 2017). Davao City also plans to install additional CCTVs to capture key facilities and each intersection in the city (ASEAN 2018). Likewise, the city has partnered with IBM to develop a centralized operations dashboard where information from various city agencies is incorporated and processed in real time, enhancing responses in disasters and emergencies (Madrazo-Sta. Romana 2012). According to the DILG, Davao City's Converged Command and Control Center project has reached 2 of the 5 implementation phases (Chavez 2021). These included installing additional CCTVs, fiber optic cables, underground cables, and digital infrastructure deployment (Chavez 2021). Another smart city initiative is the Davao City Disaster Radio, which went on air in 2020 to give information on LGU activities, particularly disaster preparedness (Davao City Government 2020). The plan is to involve the entire Davao region through a partnership with Region XI governors, with some governors already signing a manifesto to express their support for the radio (Davao City Government 2020). The Armed Forces of the Philippines has also signed a memorandum of agreement (MOA) with the LGU to help relay disaster preparedness-related information (Davao City Government 2020). Davao City also has the Central 911, which allows constituents to connect to the nearest emergency responders (Davao City Government 2018a). The LGU collaborated with the DLPC initially in 1997 for the Davao City Street Lighting Project to build light poles that can be located through GIS (DAP 2020). An engagement was also made with the DLPC for the Emergency Computer-Aided Dispatch for Central 911, which was launched in 2002 (CHMI 2021). An application developed by Auspex enables Central 911 staff to locate emergencies through GPS (Suarez 2018). The Central 911 also has an integrated public alert warning system to facilitate communication during emergencies (Cantalejo 2013). The city has also partnered with Sun Cellular, Smart Communications, Globe Telecom, and PLDT to enable mobile access of constituents to Central 911 (DAP 2020). In Davao City, public utility vehicle drivers are issued identification cards with QR codes to track traffic violations easily (Canedo 2018). According to Davao City Transportation and Traffic Management Office head

Dionisio Abude, around 19,000 identification cards have been released, and drivers without IDs would be apprehended starting in 2018 (Canedo 2018).

Because of the COVID-19 pandemic, some cities in Metro Davao have implemented smart city initiatives using technologies that can help sense, monitor, process, and communicate health and well-being data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life. The City of Davao uses QR codes to notify its constituents of contract tracing protocols and personalized status (e.g., suspected COVID-19 carriers) (Miranda 2021). It also launched the Safe Davao QR, a platform for travel passes and contact tracing (Davao City Government n.d.-b). As part of its plan to develop an integrated COVID-19 vaccination database, the LGU has been importing data on the vaccinated into a system, according to Former Mayor Sara Duterte-Carpio (Llemit 2021). These initiatives are useful, especially in emergency situations.

Some initiatives under the service phase in Metro Davao focus on industry and innovation. These initiatives help process and communicate industry and innovation data and information by, from, and to institutions to attain a competitive economy. The Davao City LGU partnered with data technology firm Fusionex International to launch the Electronic Halal Hub Trade Facilitation Platform for products of Mindanao small and medium enterprises (Padillo 2020). The LGU has also enabled online business permit applications (Davao City Government 2018b). Hijo Resources Corporation in Tagum City also plans to establish Hijo Central. According to Rosanna Tuason-Fores of Hijo Resources Corporation, the initiative is envisioned as a smart city—a hub for biotech, agritech, and foodtech (Alama 2019). She added that a platform would be in place to link farmers to the market directly (Alama 2019). Hijo Central would also feature a food innovation hub (Perez 2019). A project like Hijo Central can be a pilot area for implementing smart city initiatives.

Other HUCs

Some HUCs are increasingly incorporating digital aspects into their development plans. For instance, General Santos, Iligan, Puerto Princesa, and Zamboanga launched their 5-year digital city roadmaps in 2021 (Balinbin 2021). These roadmaps, which are part of the Digital

Cities Program, aim to improve the readiness of nonmetro localities for the digital economy. In addition, General Santos City was recognized by the Digital Governance Awards for its use of GIS in assessing climate and disaster risk in its Comprehensive Land Use Plan (DICT 2019b). Other cities are also working on establishing their cities as innovation hubs. Iloilo, for instance, crafted the "Innovate Iloilo" roadmap, which focuses on using science, technology, and innovations (STI) to improve governance (Santiagudo 2019). Meanwhile, Bacolod's TriCity ICT Caravan program aims to spur the growth of its IT-BPM sector (Nicavera 2020). These efforts show the growing commitment of HUCs to become smarter cities.

Infrastructure phase

Some of the remaining HUCs have implemented projects to improve connectivity in their areas, increasing the potential to process and communicate data and information by, from, and to the people and institutions to attain a high quality of life. In 2020, Baguio City signed an MOA with the DICT to establish a broadband network and accelerate the implementation of its Free Wi-Fi in Public Spaces Program (DICT 2020b). In partnership with the DICT, Lucena City also launched more free Wi-Fi sites as the city transitions to the new normal (DICT 2020c). Meanwhile, the PLDT expanded the coverage of its fiber and wireless networks and fiber-to-the-home infrastructure in Puerto Princesa and expanded its Smart Barangay Connect to General Santos City, Cagayan de Oro City, and Iligan City (Smart Communications 2021). Also, in partnership with the PLDT and Smart, free Wi-Fi via Google Station will be deployed in Iloilo City (Lena 2019). Additionally, Bacolod City met with Converge ICT Solutions in 2021 to discuss plans to provide fast fiber internet service for its citizens (Guadalquiver 2021). These efforts to increase connectivity in these areas show the importance of building the necessary tools or infrastructure to enable smart city technologies to flourish.

ICT platforms, such as Tech4ED, are also being deployed in different cities and municipalities. Aside from being a conduit for government services, the Tech4ED centers are also portals for information, communication, technology, nonformal education, skills training, telehealth, job markets, and business services (see DICT n.d.-e.;

PSA n.d.). Other notable digital hub projects of HUCs to enhance the digital skills of its citizens are Butuan City's DigiBayanihan and DICT's digital hub in Zamboanga City (DICT 2020d; EIFL n.d.). These initiatives not only enable more efficient delivery of services but also empower citizens to be more digitally literate.

Data phase

Some of the initiatives under the data phase relate to the sensing, monitoring, processing, translating, and communicating safety, security, and quality environment data and information to attain a high quality of life and sustainable environment. For instance, the Philippine Institute of Volcanology and Seismology (PHIVOLCS) signed an MOA with eight cities[5] to implement the GeoRiskPH (USAID 2021). This initiative will use platforms to collect and process hazard data and risk information for more efficient disaster risk management (USAID 2021). Meanwhile, the DOST and ADMU piloted smart groundwater monitoring systems to improve resource management in certain water-critical cities in the country (DOST-PCIEERD 2020b). Most cities included in the pilot areas are HUCs, including some Metro Manila cities, Iloilo City, Zamboanga City, and Cagayan de Oro City. Since the Philippines is a tropical country and part of the Pacific Ring of Fire, initiatives to manage climate-related impacts are important.

Service phase

HUCs also have civic and social initiatives using service phase tools that process and translate data and information by, from, and to the people and institutions to attain a high quality of life. For example, Iloilo City has the City Serve portal and mobile app to ease transactions and make government services more accessible (Lena 2018). Meanwhile, the Digital Governance Awards recognized Baguio City's Electronic Budget Operations and Monitoring System (eBOMS) and Cagayan de Oro City's electronic budget system as world-class ICT systems (DICT 2019b).

[5] The eight cities are Batangas City, Cagayan de Oro City, General Santos City, Iloilo City, Legazpi City, Puerto Princesa City, Tagbilaran City, and Zamboanga City. Five out of these eight cities are HUCs.

In response to the pandemic, other HUCs such as Iloilo, Tacloban, and Zamboanga also implemented contact tracing apps and online vaccine registration platforms (Burgos 2020; APEC 2021; City of Zamboanga 2021). These efforts address issues on health and well-being by helping in sensing, monitoring, processing, and communicating data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life. The different COVID-response apps can also be used to improve the healthcare systems of the cities.

Other HUCs also focus on safety and security through initiatives that can be categorized under the service phase. In 2021, Baguio City inaugurated its Smart City Command Center (Agoot 2021). Partnering with Cisco Systems, Inc., the command center will use the Smart City System, the country's first single smart city platform (Daroya 2021). Components of this include an integrated communication platform, a video management system with video analytics, computer-aided dispatch, and GIS (Amadora 2020). The project will be implemented in three phases. Aside from this, Baguio City has invested in other technologies for digital governance, crowd density monitoring, and real-time weather prediction (Dharmaraj 2020b). Meanwhile, Puerto Princesa City invested in a smart lighting system to address road accidents and street crimes due to inadequate lighting facilities (Abad 2019). The lighting system is also envisioned to address issues with power interruptions in the city (Abad 2019). Cagayan de Oro City and General Santos City are also working on completing their traffic light and signalization system with CCTV in their respective cities (see CDODev 2018; *MindaNews* 2021). Additionally, as part of Baguio's smart city system, the city plans to invest in a Smart Mobility System using artificial intelligence for traffic management and contactless apprehension (See 2021).

Other non-HUCs

Many non-HUCs have also started crafting their digital city roadmaps. For instance, Balanga, Batangas, Legazpi, and Tuguegarao launched their digital city roadmaps in 2021 (Balinbin 2021). These were made possible through the Digital Cities, a program of the DICT in cooperation with the IBPAP and Leechiu Property Consultants (DICT 2021a) to

foster development beyond the metro areas by helping identified cities[6] prepare for the digital economy (DICT 2021a). Given these initiatives, more areas are expected to develop into smart cities.

Infrastructure phase

Compared with their HUC counterparts, most non-HUCs in Metro Clark,[7] Cebu,[8] and Davao[9] have reported fewer smart city initiatives except for some cities like San Fernando. Most of them only cited enhancing internet connectivity and using online platforms for different services, but not much on implementing smart initiatives specific to their cities. A roadmap study for sustainable urban development in Metro Cebu was done by the Metro Cebu Development and Coordinating Board (MCDCB) in partnership with JICA in 2015. Some of the proposed projects that can be regarded as smart city initiatives are the development of rail-based public transport services to connect the different cities and municipalities in Metro Cebu; the Smart South Road Properties (SRP) Development, which is an IT-concentrated business center; and the Unified Management System of Energy Supply and Demand project (JICA 2015). However, an online search for updates on the projects yielded only the Smart SRP Development, mostly concentrated in Cebu City, which is in the works as of 2021. It may also be the case that online resources on smart city initiatives in non-HUCs in metropolitan areas are scarce. However, it is important to note that these results are not definitive, given that only a quick online search was done.

Meanwhile, as of November 2021, the Free Wi-Fi program of the DICT has already put up 11,475 free Wi-Fi facilities across the country (Rita 2021). Given the importance of internet connectivity in making

[6] The 25 cities included in the Digital Cities Program are: Balanga City, Batangas City, Cabanatuan City, Dagupan City, General Santos City, Iligan City, Iriga City, Laguna Cluster (Calamba, Los Baños, and San Pablo), Laoag City, Legazpi City, Malolos City, Metro Cavite (Bacoor, General Trias, and Imus), Metro Rizal (Antipolo, Cainta, and Taytay), Olongapo City, Puerto Princesa City, Roxas City, San Fernando City (La Union), San Fernando City (Pampanga), San Jose Del Monte City, Tacloban City, Tagbilaran City, Tarlac City, Tuguegarao City, Urdaneta City, and Zamboanga City (IBPAP 2020).

[7] Non-HUCs in Metro Clark and their income classes: Mabalacat City (3rd) and San Fernando City (1st)

[8] Non-HUCs in Metro Cebu and their income classes: Carcar City (5th), Danao City (3rd), Naga City (5th), and Talisay City (3rd)

[9] Non-HUCs in Metro Davao and their income classes: Digos City (2nd), Panabo City (3rd), Samal City (4th), and Tagum City (1st)

the government's response to the pandemic efficient, the program's implementation was accelerated, especially providing connections to geographically isolated and disadvantaged cities and municipalities (DICT 2021b). However, in a study by the ADB and Thinking Machines, there is still a huge disparity between the internet speed of the wealthiest and poorest cities (Sy et al. 2021). The average internet speed in the wealthiest cities is 21 Mbps faster than in the poorest cities (Sy et al. 2021). Although increasing internet coverage is essential in bridging the digital divide among regions, the quality of the internet is also as important for it to be effective.

Another effort of the government to further bridge the digital and education divide across regions in the country is the Tech4ED project of the DICT, which aims to improve citizens' access to different information resources and services. As of 2020, there were already 4,544 Tech4ED centers across 81 provinces (PCOO 2021).

Service phase

To improve service delivery, some initiatives under the service phase can help sense, monitor, process, translate, and communicate civic and social, as well as health and well-being data, information, and knowledge by, from, and to the people and institutions to attain a high quality of life. Implementing the Integrated Business Permits and Licensing System (iBPLS) Project and CBP of the DICT has necessitated LGUs to digitize their systems. As of November 2020, 159 LGUs have already been supplied with the iBPLS-cloud system (PCOO 2021). Several cities are also utilizing online applications for their COVID response efforts. The use of digital-based initiatives has become more critical due to the nature of the issue. Contactless measures are recommended to prevent the further spread of the virus. While some LGUs developed their own contact tracing applications, some opted to adopt existing applications such as the StaySafe.ph application launched by the Philippine government. According to a DILG official, around 700 LGUs already use the StaySafe.ph application as of March 2021 (DILG 2021). While creating their own contact tracing applications is a commendable initiative, the government, in this case, is advocating for the LGUs to adopt the StaySafe.ph app for easier overall tracking (DILG 2021) instead. The need to unify the systems of LGUs is preferable for the pandemic to be managed more

effectively (DILG 2021). To achieve this, the government is also working on integrating the existing systems of LGUs (DILG 2021). The importance of having interoperable systems is highlighted here.

Additional areas

Additional areas are notable in a Google search for smart plans and/or implemented smart actions in the Philippines. These involve initiatives under the infrastructure and service phases. For instance, Cauayan City, despite not being in a metropolitan area, has been making waves in terms of implementing smart city initiatives. PLDT has rolled out a fiber-powered fixed broadband network in the city, and Smart has enabled 4G or long-term evolution (LTE) mobile data services (Smart Communications 2019b). In addition, the city has an IoT-based aquaponics, whose stakeholders include Isabela State University and Singapore's Temasek Polytechnic; synchronized clocks; LED screens near farms for weather updates; and a "Cauayan City Connect!" application for cashless payments, feedback, updates, emergency hotlines, and maps (Poon and Shiyuan 2019). Cauayan City also planned to install kiosks for government-related payments (MultiSys n.d.). Meanwhile, in the Municipality of Carmona, there is a plan to use solar power for electricity and develop a bus rapid transit, according to the SM Development Corporation President Jose Mari Banzon (Municipality of Carmona 2021). In addition, New Clark City, a smart city project expected to address issues in Metro Manila's urban infrastructure, is planned to have an energy management and storage system and a district cooling system (Mouton 2021). The smart plans and actions of the areas encourage further reviews on the sites.

Missing link

The overview of smart city initiatives provides an idea of the various efforts exerted across the smart city development phases. Many initiatives are under the infrastructure phase. LGUs appear to know the importance of increasing access to the internet as part of the activities under this phase. Their efforts also reflect the desire to break away from the limited connectivity in the country that prevents cities and municipalities from taking advantage of technologies. Infrastructures for sustainable development also exist, including mobility and environmentally useful technologies.

Many initiatives are also under the service phase. Numerous civic and social initiatives involve deploying platforms to enable e-government transactions. Health and well-being are also the focus of some initiatives, such as those used for COVID-19 contact tracing and monitoring of related efforts. Meanwhile, initiatives under the service phase include the development of command and control centers for safety and security.

There are fewer initiatives under the data phase, and most have a civic and social focus. Examples of these initiatives include feedback platforms and safety and security applications that serve as avenues to report emergencies or crimes. Suppose the reviewed online resources mimic the reality of the status of the data phase in the Philippines; in that case, these initiatives appear insufficient, given that smartness relies heavily on data.

The smart city initiatives of some LGUs in the Philippines are noteworthy, but the relayed information is potentially lacking. The extent of smart city development in some cities might not be adequately represented because of search limitations. Furthermore, the progress of the mentioned smart city initiatives should be validated with the LGUs to update these findings. A more in-depth review of the experiences of cities would also create an opportunity to determine suitable pathways for implementing smart city initiatives and addressing challenges. The lack of research on the drivers and extent of smart city development in the Philippines and the appropriate ways to implement smart city initiatives makes it challenging to gauge Philippine cities' readiness for smart city development. Hence, the next section discusses an assessment of enablers, barriers, and pathways for smart city development in the country.

Initiatives in Selected Sites and Interview Themes[10]

Definition

A word frequency query was conducted using NVivo11 to find the top 100 descriptive words the respondents mentioned concerning the definition of a smart city (Figure 7). The top 10 descriptive words were: development, digital, sustainable, right, safe, quality, public, efficient,

[10] See Annexes 1 to 12. Note that some quotes in this section have been translated to English.

local, and national. Development and digital were used more than 200 times across all participants.

Based on the interviews, the country still has no universal definition of smart city. Definitions by NGAs were adopted from different local and international development frameworks. However, most of these frameworks have different focus areas, leading to definition variations. Moreover, every NGA has its unique mandate influencing how it participates in project implementation at the national level. As shared by a representative of the DILG, "…for the DILG, we are espousing the digitalization, resiliency, urban governance among our cities… We do not have an official tagline or definition for the smart [city]."

Figure 7. Most frequently used words to describe smart cities

IoT = Internet of Things
Source: Authors' illustration

Meanwhile, LGUs usually define smart cities as the efficient use of technology to improve service delivery, public safety, sustainable development, and the environment. For them, the overall outcome of developing smart cities is to enhance the quality of life of their people. The Cauayan City LGU shared that LGUs do not realize yet that they are already implementing smart initiatives in their city, implying the need to increase the understanding of LGUs on the smart city framework and how their initiatives can be incorporated into that framework. The LGU also emphasized the idea that being highly urbanized, metropolitan, or rich is not a requirement for smart city development.

Moreover, various key performance indicators and frameworks are readily available for LGUs. One respondent pointed out that initiatives do not have to be grand, highly complex, and technical to be considered smart city initiatives. The important aspect of it is that this technology was able to address the needs of the people.

For private partners interviewed in this study, they defined a smart city as taking advantage of technology to ensure economic growth and a sustainable environment. Interviewed development organizations described their role as "making cities future-ready" by efficiently using available technology to address specific issues.

Moreover, they noticed that the level of readiness for smart city development varies across national agencies and LGUs. One respondent from the development organization pointed out the need to harmonize various smart city initiatives to avoid duplications, given that different stakeholders have visions or priorities in developing these projects.

Motivations

Annex 13 describes the various motivations of LGUs for initiating smart city projects. Most responses can be categorized into providing high quality of life, addressing public issues, supporting informed decisionmaking, supporting development and sustainability, and replicating best practices, corporate social responsibility (CSR), and business prosperity. Hence, the focus of these initiatives reflects the motivations of the proponents.

Under the civic and social focus, the Cauayan City LGU has been implementing the Juan Time Campaign of the DOST, which promotes using the Philippine Standard Time, setting one common time across the country, and providing weather updates (see DOST 2015).

Under health and well-being focus, Tuguegarao launched the MyCure System in partnership with the DOST to facilitate online medical consultations.

San Fernando City in Pampanga has installed a command and control center and an online business registration facility for safety and security and built infrastructure. According to former Mayor Edwin Santiago, the PHP 220 million financing for the command and control center, inaugurated in 2020, came from the LGU's 2018 savings and contributions from the business sector (Arcellaz 2020). Under this project, 110 bullet cameras and 26 video walls were installed. In Tagum City, smart solar-powered street lighting was installed. Also, for safety and security, a command center in Tuguegarao City has been established as a real-time monitoring center with CCTV and is operated by the Philippine National Police and Bureau of Fire Protection (see Tuguegarao City Government 2021a). Another initiative under this focus is Cauayan City's deployment of drones to keep constituents safe, capture criminals, and implement lockdown restrictions. For instance, Barangay Cabaruan (2020) started using drones in 2019. Three drones were also deployed in Cauayan to monitor constituents during the COVID-19 lockdown (Visaya 2020). Another project focusing on safety and security is the traffic management system in Mandaue, which uses CCTV cameras and sensors the city obtained in the 1990s (see Talisic and Sotto 2018). Furthermore, Mandaue entered a proof of concept agreement with Dyna-Tech and HUALU e-cloud to develop a no-contact apprehension system (Palaubsanon 2019).

Under the focus on quality environment and built infrastructure, Tagum City uses Euro 4-compliant heavy equipment and vehicles to reduce greenhouse gas emissions.[11] Meanwhile, for the quality environment and industry and innovation focus, the Cauayan City LGU, in partnership with the Temasek Polytechnic University and Isabela State University, created an IoT-based aquaponic system, and 160 households in Sitio Manalpaac were given livelihood assistance. In San Fernando City, an initiative under quality environment is the installation of solar panels to serve as an additional energy source.

When asked about their motivations for implementing smart city projects, most LGUs said they want to improve their service delivery,

[11] Euro 4 is a European emission standard on the use of clean vehicle fuel with low benzene and sulfur contents (*BusinessMirror* 2022).

sustain the environment, and develop a competitive economy/business to enhance the quality of life of their constituents. This is aligned with how they define smart cities. For them, improved service delivery can be as complex as using high-tech equipment like sensors, high-definition CCTV cameras, and drones. It can also be as simple as providing timely weather reports for farmers. Some LGUs wanted to showcase that even nonurbanized agricultural cities can develop into smart cities.

To uphold the Ease of Doing Business policy and alignment with the Local Government Code, LGUs use technologies to improve service delivery, such as digitalizing construction and business permit applications and encouraging contactless transactions for PhilHealth claims and tuition fee payments. Provision of these services to their constituents can eventually improve the quality of life in terms of health and well-being, public safety, competitive economy, and sustainable environment.

Numerous initiatives aligned with the policy on ease of doing business exist. For example, the Cauayan City App, developed through a partnership with the Multisys Technologies Corporation, enables transactions related to e-government, e-bills, e-commerce, e-services, and e-wallet. The second version of the app was launched in 2019. The Cauayan City Identification Card, a product of a collaboration with GCash, also went through different versions. From being a simple ID card in 2014, it became ATM-enabled in 2015 and Mastercard-enabled in 2018. So far, about 5,000 IDs have been distributed by the Cauayan LGU, and kiosk machines have been deployed to facilitate bills payment. Meanwhile, smart city initiatives of Malabon City include the GIS-complemented computerization of tax collection data and transactions in revenue-generating departments (Melican 2013). It was financed through an internal budget of PHP 3.8 million, including the software license fee, equipment deployment and setup, and training (Melican 2013). Malabon partnered with IB Solutions IBS Worldwide Corporation in 2020 to facilitate online transaction payments (Lim 2020). Meanwhile, in Mandaue, an electronic business permit and licensing system was developed in partnership with the DICT in 2021 (see *SunStar Cebu* 2021; Mandaue City Government and DICT n.d.). According to Business Permit and Licensing Office head August Lizer Malate, the official business permits would be issued with security stickers and

QR codes for authenticity validation (see *SunStar Cebu* 2021). Meanwhile, Tagum City uses LED walls, television, radio, print, and social media to disseminate information.

Most LGUs believe that their smart city initiatives will help them plan and respond to the needs of their people, as these initiatives allow them to collect and analyze data and, consequently, make informed decisions, especially in times of disaster and pandemic. Likewise, most LGUs decided to engage in smart city initiatives while exploring ways to address challenges such as disaster risk response, public safety, transportation, and traffic management. Further, the COVID-19 pandemic made them realize the importance of using technology to collect the necessary information to make informed decisions.

LGUs also shared that they wanted to capitalize on the available resources to promote better life in their cities. For example, the "Transformative Mindanao" concept was launched to revolutionize agriculture in Tagum and throughout Mindanao. The LGU is also keen to make itself a "cleaner" city by establishing infrastructure for e-vehicles. Meanwhile, San Fernando City focused on providing fiber connectivity for better service delivery, while Mandaue City initiated projects focused on renewable energy in far-flung areas and promoted recycling to produce alternative fuel sources for construction businesses.

LGUs exposed to the success of smart cities abroad have also been motivated to learn more about smart cities and how they can be applied in their hometowns.

Meanwhile, most partners from the business and development organizations pointed to CSR as the main driver for engaging in smart city initiatives with LGUs. Some private partners interviewed for this study provided free technical assistance, while some shared company assets for free, especially during disasters and for COVID-19 response. Some private partners also find engaging in smart city initiatives an opportunity to maintain good working relationships with their city and clients.

Business partners highlighted the importance of protecting their clients and the community for business prosperity. They see engagements in smart city initiatives with LGUs as opportunities to become good corporate citizens and serve the underserved. Also, some business

partners noted that "[whatever is] good for the people or city [is also] good for business."

On the other hand, development organizations assist LGUs in addressing pressing issues in their respective areas in line with their objectives. For example, an organization assisted in addressing waste management issues of an LGU by tapping an international technology SME. Some development organizations also assisted an LGU in modeling their city roads using their technology. Another development organization supported an LGU on its ICT-related projects to help the business sector. Meanwhile, another organization worked with the academe to establish an innovation hub to ensure that startups were supported and to address Sustainable Development Goal (SDG) 8 on decent work and economic growth. Finally, one organization supported an LGU to ensure that development would not compromise the environment.

NGAs' participation in smart city initiatives is mainly driven by their mandates to ensure that public issues are addressed at the national level. Some of the problems highlighted include (1) achieving SDGs (DOST-PCIEERD); (2) upholding the Data Privacy Act (NPC); (3) ensuring cybersecurity (DICT); (4) establishing better internet connectivity and provision of free Wi-Fi access and other ICT-related assistance in COVID-19 response (DICT); (5) improving the processing of business requirements and licensing (DILG); (6) alignment of proposed infrastructure projects in existing national and regional development plans and resiliency measures like addressing climate change and disaster risk reduction measures (PPP Center).

NGAs also highlighted LGUs' interest in pursuing smart city initiatives. As observed by a representative from DOST-PCIEERD, local governments also aspire to be innovative and be the first to introduce smart city initiatives usually to address challenges in their localities.

NGAs also value the importance of learning best practices here and abroad to guide the country's implementation of smart city initiatives. Participation in different smart city-related organizations not only helps design a policy blueprint for Philippine cities to adopt but also increases access to opportunities for funding assistance through grants.

Respondents also noted the importance of increasing connections or networks locally and globally and improving the monitoring and evaluation of different national programs.

Apart from LGUs, the interest of stakeholders in implementing smart city initiatives is evident, and some examples provide insights into their motivations. For instance, Tagum has a waste-to-energy plant project under the PPP Center (PPP Center n.d.-d). The project costs PHP 757.61 million, with Global Green International Energy Philippines Inc. as the private sector proponent (PPP Center n.d.-d). Likewise, Hijo Resources Corporation's Hijo Central, the proposed biotech, agritech, and foodtech hub, is also expected to contribute to Tagum's smart city development. Meanwhile, Mandaue LGU's smart initiatives include the APEC Low Carbon Model Town Project, the use of solid waste management technologies, and the installation of fiber broadband connections. For the APEC Low Carbon Model Town Project, a feasibility study was published by ALMEC Corporation in collaboration with Ernst & Young Advisory Co. Ltd. and Michi Creative City Designers Inc. in 2017 (ALMEC Corporation et al. 2017). Some of the activities under this project are developing the Green Building Program, solid waste management technologies, and modeling urban heat islands. The LGU has invested in the project through its Annual Investment Program (AIP). The Green Building Ordinance of Mandaue City also supports the initiative. In line with the environmental agenda of Mandaue, the Department of Environment and Natural Resources-Environment Management Bureau (DENR-EMB 2021) signed an MOA supporting the donation of 13 units of rotary drum composter, biodegradable waste shredder, and solar-powered 4G network camera. Financed by Vivant Foundation, bike repair stations were also installed in Mandaue City (Sagarino 2021). A tripartite MOA with Vivant Foundation and Mandaue Chamber of Commerce and Industry was signed in 2021 to support the installation (Sagarino 2021). Lastly, the LGU partnered with Converge to deploy fiber broadband services to improve connectivity (Diangson 2021).

Enablers

This section describes the enabling factors for implementing smart city initiatives successfully from the respondents' perspective. Identified key enabling factors include partnerships with other agencies, compliance with existing policies and guidelines, certifications, having an ICT department or staff, having smart city champions, access to technology, and existing infrastructures (see Annex 14).

Partnerships

For LGUs, one of the main enabling factors is their engagement with other agencies. Partnerships with the private sector and NGAs allow LGUs to learn from them and utilize their technology, systems, and even funding to implement smart city projects to improve service delivery. This was reiterated by one of the respondents interviewed:

> *"I think partnership, partnership, partnership plays a very, very important role, whether it be partnerships with the academe or the private sector. But it is very important to get everybody on board, and you will eventually get a lot of solutions providers also that would want to partner with you. That will make it sustainable."* – Interview with Cauayan City LGU

Meanwhile, private partners' emphasis on strong partnerships with LGUs is the main enabler for developing smart city initiatives. They perceive LGUs as their biggest stakeholder; hence, the success of any smart city project relies on the willingness of LGUs.

At the national level, NGAs see the importance of a multisectoral approach in implementing smart city initiatives. For them, partnering with other NGAs and international organizations is an important source of funding support. They also see the major role of universities as training grounds to develop smart people for smart cities. Hence, they understand that a strong linkage with the academe is essential to the success of smart city projects.

Finally, constant stakeholder communication builds trust, strengthens partnerships, and ensures that initiatives are not duplicated. If information is available, development organizations and business partners can easily identify which priority areas they can focus on, thus helping prospective partners develop project proposals. Examples are the availability of feasibility studies or even city development plans that can guide partners in identifying projects with LGUs.

Examples of initiatives explored through partnerships include the Cauayan City LGU's project with PLDT to install fiber optics in the city (Cabuenas 2019). Cauayan City also has an e-charging station and had an e-tricycle prototypes parade made possible through a collaboration with stakeholders such as the DOST, which provided financial support,

Isabela State University, the University of the Philippines (UP) Diliman, and private manufacturers and sellers of e-tricycles and e-bikes (Almirol 2017). Two chargers have already been installed for e-tricycles (UP EEEI n.d.). E-scooters equipped with an application for control and global positioning systems for tracking were also launched in a turnover ceremony in 2020 (Pinas 2020). For the project, an MOA was made with the DOST, Isabela State University, UP Electrical and Electronics Engineering Institute, and FILGENIUS (Pinas 2020). Seven e-scooters were turned over to the Cauayan City LGU (Munchang 2020). In addition to the e-scooters, the LGU has a hybrid electric road train with four air-conditioned interlinked cabins for 200 passengers, which was designed by the DOST's Metals Industry Research and Development Center and launched and turned over in 2019 (Domingo 2019).

Cauayan City also has the Cauayan City Care COVID-19 Consult, a telemedicine project developed and operated by the Isabela State University in collaboration with the LGU, DOST, Commission on Higher Education, and Dynamic Outsource Solutions Inc. (Domingo 2021). In addition, the Cauayan City LGU launched a digital twin, a 3D map of the city converted from drone photos and equipped with AI for disaster damage estimation (Yun Xuan 2021). The digital twin was built in 2020 by the Singaporean startup company Graffiquo (Tan 2021). According to the LGU drone team head Cornelius Dalog II, 0.5 square kilometers of waterfronts were captured in two days by his team, and 3D landscape models were then created with the help of Graffiquo (Graffiquo 2020). The Tuguegarao City LGU has also been working on developing a digital twin with the support of the Cauayan City LGU (Yun Xuan 2021).

Technical and funding support

The availability of funding opportunities for smart cities from national agencies like DOST-PCIEERD opened opportunities for LGUs to benchmark with the best practices from successful smart cities abroad. Aside from funding support, NGAs such as the DICT, DOST-PCIEERD, and PPP Center also provide technical support to the LGUs through consultations.

Some of Cauayan City's initiatives were made possible through support from the public and the private sector. These include the PATURO, which consists of a data hub linked to a visualization platform to derive insights into the transport network (DOST-PCIEERD 2020c). Launched in 2020, the project is financed by the DOST-PCIEERD and conducted in partnership with the Asian Institute of Management, Isabela State University, and the LGU (*The Manila Times* 2020). Another initiative is the deployment of RxBox to geographically isolated and disadvantaged areas (Dig 2021). RxBox, a device for measuring heart rate, oxygen saturation, and temperature, was donated by Ionics EMS Inc. to DOST (Dig 2021).

Several initiatives were facilitated through internal budgets and loans. For example, the fiber optic cabling in San Fernando under the Smart City Phase II Program was given a PHP 100-million allotment in the LGU's 2021 AIP, made possible through a loan from LANDBANK. For Tagum, the Revenue Administration and Mobilization Program, an automated and integrated management system, was financed through a loan from the Development Bank of the Philippines (DBP). Tagum also has the Traffic Signalization Project, which includes installing traffic lights in priority junctions (Tagum City Information Office 2018b) and traffic surveillance cameras to monitor traffic violations. This project was contracted out to the Traffic Supplies & Construction Corporation and was financed through a loan from the DBP. Meanwhile, Malabon LGU allocated an internal budget of around PHP 9.99 million in 2017 to install CCTV cameras for emergency monitoring (see Malabon City Bids and Awards Committee 2017). On the other hand, Mandaue invested at least PHP 79 million in 2013 to install digital clocks and high-definition cameras along 13 major intersections. The city also planned to install additional traffic lights costing PHP 5 million (Talisic and Sotto 2018). Another initiative in Mandaue is the development of a *purok* database system, which received a budget of PHP 12 million from the LGU's 2021 AIP.

Compliance with existing policies and guidelines

National policies, laws (e.g., Local Government Code), and guidelines nudge LGUs to engage in smart city projects to improve

service delivery. Many LGUs mentioned that RA 11032 led them to automate their transactions for business and construction permit applications and renewals. These policies and guidelines also allowed more LGUs to streamline their processes and use online platforms, such as telemedicine, online matriculation payment processing, and authenticating legal documents. Some LGUs even assign people to monitor new guidelines they can apply to serve their constituents better. Through local ordinances and policies, LGUs can ensure private partners deliver their responsibilities in PPP initiatives, especially in massive infrastructure projects. Moreover, local executive orders and ordinances ensure public compliance with smart city projects. In Cauayan City, some resolutions have been issued from 2005 to 2019 to facilitate the installation of cell sites, expansion of cellular network systems, and provision of Wi-Fi services by a telecommunications company. Through a resolution, the LGU also set up a water quality testing laboratory in partnership with the DOST and Isabela State University.

Seeking certifications

Compliance with certifications like those of the ISO and Building for Ecologically Responsive Design Excellence (BERDE) encouraged LGUs to apply smart city initiatives in their governance. Seeking ISO certification led them to think of ways to digitize and streamline their processes. On the other hand, BERDE certification ensures that infrastructure projects do not compromise the environment.

Assigned ICT department or staff

LGUs with a designated ICT department or personnel can lead to better utilization of ICT technology and systems to improve service delivery. These ICT personnel not only keep LGUs up to date with technological advancements but can also advocate the use of available technologies to improve their services. Hence, continued capacity building of these trained personnel or departments is also seen as necessary for the success and sustainability of the projects.

Private partners are encouraged to engage with LGUs if the latter have digitized data or when feasibility studies were conducted. Private partners can see a potential cost reduction when these systems are already in place in their prospective LGU partners.

Smart city champions at the LGU level

Having smart city champions, especially local executives, is an important success factor in LGUs' smart city engagements. These leaders or staff see the value and advocate using the available technologies to address issues in their localities. Without vision, will, and commitment, LGUs may not be open to engaging with business partners or simply disapprove projects branded as smart cities.

Private partners perceive that if the LGU leaders are smart city champions, the likelihood of implementing smart city-related projects is high. These champions understand the importance of data and technology to serve their people better. They also recognize the business sector's role in helping them achieve their vision for their city.

The business sector is more likely to partner with LGU leaders who are willing and committed to implement smart city initiatives. An interviewee from the private sector shared that development appears to be faster if there are leaders who push for progress and appreciate new methods and technologies.

Likewise, collaboration between LGUs and businesses is essential for strong working relationships, with both delivering their roles as expected. Alignment of their objectives is also important to establish this strong working relationship.

Development organizations also see smart city champions at the LGU level as enablers of successful smart city initiatives. As cited by one respondent, it is important that LGUs have a genuine interest in implementing smart city projects and relayed an example wherein cooperation was ignited because the mayor shared a common interest with the organization in pursuing a smart city initiative.

Accessibility to technology

Access to a wide variety of technology allows LGUs to explore various communication methods with their constituents. Existing ICT infrastructure also gives LGUs leverage, especially when engaging with private partners for implementing projects. Most interviewed LGUs have the basic ICT requirements like different equipment and internet connections to run these specific systems. Most of these initiatives were from projects in partnership with the private sector and national agencies.

Numerous ICT infrastructure initiatives were identified by reviewing online resources and documents. For instance, in Cauayan City, the LGU distributed Wi-Fi routers to 65 barangays as early as 2014. Another project is the Barangay Centralized Wi-Fi Network equipped with extranet, internet, local area network (LAN) messenger, 5-gigahertz radio signal, and high sector antenna, enabling messaging and file sharing between and among 65 barangays and the LGU (DICT et al. 2020). Tuguegarao City also has smart initiatives such as the Free Direct Internet from Globe Business, which facilitates connections among offices using video applications, voice, and data (Amojelar 2019). In San Fernando City, the LGU has provided free Wi-Fi in 9 Early Childhood Care and Development Centers. Initiatives in Malabon City include upgrading 101 cell sites and installing 6 new ones for 4G connection (see Globe 2021). In Tagum City, the LGU installed an Integrated Systems Digital Network and Private Automatic Branch Exchange for its trunkline to facilitate communications made possible through an internal budget and a loan.

The availability of digitized data also entices private partners and NGAs to engage with LGUs since they can readily use or import existing databases to their systems or applications. Some LGUs are already working on the digitization of data. One initiative in Cauayan is the creation of QR Codes for constituents of Barangay Cabaruan which, according to the 2020 Census, has a population size of 8,244 (see PSA 2021k). Additionally, as part of Cauayan's COVID-19 contact tracing effort, QR Codes were used with the help of Nspire Inc. and AJ Enterprises (Dig 2020). A smarter early warning system for dengue has also been implemented using information mapping. Malabon City LGU developed a contact tracing application with QR code technology and integrated it into the City Health Monitoring System (David 2020b).

Meanwhile, through the Tuguegarao Government Portal, citizens can access online government services such as travel pass application, checkpoint registration, QR card application for residents and nonresidents, online payment, and vaccination registration (Tuguegarao City Government 2021b).

LGUs with ICT staff or departments are more able to implement smart city projects and attract partners from the private sector and NGAs. Also, joint ventures among LGUs, private partners, and the

academe increase LGUs' access to the available technology or systems. The private sector serves as a technology purveyor and provides the necessary technology to LGUs to implement relevant smart city projects.

Other enablers identified by respondents are the use of international standards, the geophysical characteristics of LGUs, and the presence of potential clients in target areas.

Challenges

When asked about the challenges or issues in implementing smart city initiatives, respondents cited the lack of interoperability and operational costs as the topmost issues. Annex 15 describes the common themes raised by respondents during the interviews.

One of the most cited challenges was the lack of funding for these initiatives, particularly in setting up the necessary ICT infrastructure. While most interviewed LGUs have existing basic ICT infrastructure, the fast-paced technological growth requires these LGUs to upgrade their systems continuously, which can be very costly. According to a respondent from an LGU, different service providers for COVID dashboards have approached them. However, they find these predeveloped systems expensive. Some smart city development-related upgrades requiring huge budgets include hardware, faster and more reliable internet connectivity using fiber optics, early warning systems, communication devices, sensors, and CCTV cameras. Aside from these hardware requirements, training and hiring competent staff to maintain and manage these systems were also costly for LGUs to implement alone. The private partners also consider the lack of infrastructure challenging since most systems require fast and reliable internet, physical space and buildings, and trained people to operate, manage, and maintain them.

The lack of funding led some LGUs to rely heavily on partnerships to finance their initiatives. Some LGUs, however, noted their reliance on private partners for funding resulted in some initiatives not materializing. Moreover, respondents see the lack of network connections with other private sector entities from which LGUs can explore partnerships and seek funding support. One NGA mentioned that this has led to vendor-driven developments of cities.

The second most cited challenge was the lack of system interoperability. According to LGUs, most systems work in silos,

with each project or initiative having its unique data collection and storage method. This often makes data collation tedious, especially during a disaster or pandemic. The differences in systems are a result of conflicting priorities of requesting offices and service providers. Despite this, some LGUs have started working on the integration of their systems for interoffice transactions.

While efforts to collect data exist, the lack thereof remains challenging for the respondents. Private partners and NGAs pointed out that data cleaning and merging datasets are problematic because it entails more time and resources. Moreover, there is an issue with data reliability. An LGU shared that when their planning office needs information about household listing for their activities, these can be derived from different offices like social services and health. However, there is still a need to verify this due to duplication and inconsistencies.

The public uptake of these smart city initiatives is also challenging, especially for LGUs. Many LGUs pointed out that the public's ability to adapt to technological innovations remains a constant but manageable issue. LGUs reckoned that the public needs a certain amount of time to understand the purpose of the initiatives and learn the ropes. Some private partners and NGAs cited this challenge, but the reason was more in the context of a lack of public trust in how the data collected will be used and stored. The level of uptake among LGU offices is also at risk. Some LGU staff are having difficulty adopting technologies intended to improve certain initiatives, including those related to real tax payment services, delivery of social services, and contact tracing.

In relation to social acceptance, digital divide was also among the issues cited by respondents. At the individual level, digital literacy was seen to influence social acceptance. Examples relate to experiences implementing online payment services, telemedicine, and contact tracing, which many target participants failed to utilize due to a lack of necessary devices and basic skills to verify their accounts electronically. NGAs are beginning to see the uneven development of the cities because of the differences in priorities, financial capability, and access to technology.

Another issue that respondents mentioned was regarding policies and standards. While there are existing policies, some respondents shared that some are not implemented properly. Meanwhile, NGAs

like the PPP Center and NPC highlighted the role of a national or even regional framework integrating initiatives. Specifically, the NPC underlined the need for a data sharing guideline. At the same time, the PPP Center wanted a framework that would ensure interconnectivity and interoperability among smart cities and their initiatives. Some LGUs also need such a regional or national framework or guidelines to help them plan and prioritize projects. An LGU raised the difficulty in coming up with an action plan given only discussions of smart city initiatives in meetings.

The different interpretations of the Data Privacy Act pose issues. The NPC shared that from the perspective of the LGUs, the cybersecurity and data privacy policies prevent them from collecting more data. LGUs become protective over their data, which can become an issue at the national level, where certain information (e.g., contact tracing data during the COVID pandemic) needs to be consolidated.

Another issue cited by most respondents was the change in administration. This is a particular concern for some private partners who perceive that leadership changes mean changes in priorities. This could threaten existing projects, especially those not institutionalized yet by an ordinance. Some LGUs also recognize this issue since implementation and funding support for smart city initiatives rely heavily on the priorities the incumbent leaders set. On the national level, some NGAs noticed that leadership changes could redirect the priorities of LGUs, threatening the sustainability of existing projects. This would mean the need to engage them again in smart city initiatives implemented at the national level.

The pandemic also posed issues, according to some LGUs and private partners. The movement restrictions delayed the implementation of many projects, particularly on the infrastructure side.

The private partners saw bureaucratic processes, such as securing permits and other requirements from different offices, as additional costs. Some business partners mentioned that the time it takes for these requirements imposes additional project costs. One participant shared that the business sector deems some regulations as a hoop since they cannot see the relevance of such policies in their infrastructure projects.

Other concerns mentioned were lack of coordination between stakeholders, duplication of some initiatives, environmental issues,

lack of monitoring or accountability in certain projects, population growth, security threats, and weather.

Pathways

When asked about the pathways to smart city development, respondents cited the following: engagement in PPPs with formalized agreements, capacity building, awards or incentive schemes, implementing pilot projects, and establishing regional hubs (see Annex 16).

Formalized agreements

Partnerships with different agencies were considered one of the pathways to implementing smart city initiatives successfully. LGUs have been engaging with the business sector, development organizations, state universities, and national agencies to augment funds and access technology or systems, equipment, and training for them to implement initiatives. The DICT and other telcos provide support for implementing business permits and licensing systems. A local ICT company supports its city in developing an app-based emergency reporting system that connects to some response teams, including volunteer groups. Initiatives involving huge infrastructure investments were materializing with the help of business partners. With the impending implementation of the Mandanas-Garcia Supreme Court Ruling, LGUs are expected to collaborate with private partners to address the additional tasks the policy entails. This was seconded by the PPP Center, which relayed in an interview the expectation that LGUs will engage more in PPP to diversify the manner in which they deliver services.

Some LGUs shared that their partnership allows them to touch base with international agencies where they can also seek assistance through grants. One development organization deemed partnership as one way to address financial concerns in implementing smart city initiatives, sharing that it spreads funding across LGUs.

Formalized agreements often strengthen these partnerships. Most of the respondents mentioned that MOAs are prerequisites for an initiative to take place. Ordinance issuance was also seen to ensure that projects would continue despite changes in leadership at the LGU level. Ordinances will also ensure that projects will be considered in budget

allocations at the local level. While these do not guarantee the success of the smart city initiatives, it provides the private partners and even LGUs a sense of security and commitment to the project, which is a foundation of a good partnership. These documents also help provide assurance that donated funds from international organizations would be used accordingly in the proposed smart city projects.

The usual partnership process can come from the barangays, LGU departments, or private partners. They usually present their proposal to the local council for approval and endorsement. Once a proposal has been endorsed, the agreements between project stakeholders will occur through MOA or issuance of ordinances or policies. While most proposals came from private partners, initiatives from LGU departments like ICT and planning offices were common.

There are numerous examples of engagements with formalized agreements. San Fernando's free fiber-powered Wi-Fi in the city hall and old public market is a donation made possible through an MOA with Smart in 2019 (*SunStar Pampanga* 2019a). San Fernando also has an online platform for business permit transactions, payment of business taxes (see Arcellaz 2022), and an option to deliver business permits (*SunStar Pampanga* 2019b). For the delivery of permits, Resolution 2018-024 was issued for an MOA with 2Go Express Inc. according to Business License and Permit Division Chief Joseph Garcia (*SunStar Pampanga* 2019b). Meanwhile, Mandaue has its Guardian Emergency Response System, consisting of a free mobile application for reporting incidents or requesting assistance and software for dispatch and deployment (*SunStar Cebu* 2018). An MOA was signed with the software developer Sugbotek Inc. for the adoption (*SunStar Cebu* 2018). Additionally, Cauayan City's waste-to-energy plant that generates energy using waste products from Cagayan Valley is supported by an MOA with Clean World Sustainable Solutions Inc. and other Metro Cauayan and Isabela LGUs (Domingo 2016).

Capacity building

Aside from partnerships, respondents highlighted the importance of capacity building in implementing smart city projects. Tagum City LGU highlighted the importance of capacity building for the departments,

not just the leaders, to ensure that a specific group of people will operate and maintain the systems.

> *"I see to it that (they are) capacitated... provided with the necessary trainings, and experience, and exposure. The heads of offices, the bureaucrats, and see to it that logistically we are provided (with) the necessary equipment, mobility, and hardware computer."*– Interview with Tagum City LGU

Capacity building for the public can also be done through constant training, like the initiatives of some cities to support their SMEs. Some LGUs have initiatives called the Technology Ecosystem Development (TED) Plan and the Business Intelligence Research and Development Center (BIRD-C) in partnership with local universities to attract investors. Tuguegarao City LGU has also been capacitating its local talent through a digital literacy training program.

NGAs acknowledged the importance of capacity building and shared some of their initiatives. For example, the NPC conducts summits and training for nongovernment organizations, business process outsourcing companies, LGUs, and technology organizations about the Data Privacy Act. They also partner with DAP to develop training courses for this. The DOST-PCIEERD has collaborated with DAP for SPARTA, which offers human resource development courses. The DOST-PCIEERD also has the GODDESS initiative to provide funding for capstone projects from SPARTA. The main objective is to encourage students, universities, public servants, and researchers to collaborate and create solutions for public issues locally.

Incentive codes and awards schemes

According to some LGUs, incentivizing projects is one way to entice engagement from private partners within their cities. For example, the Tuguegarao City LGU shared that they recently amended their incentives code to attract ICT investments. The Cauayan City LGU also has investment webpages to announce investment opportunities and incentive packages (see Cauayan City 2019). NGAs like the NPC, DILG, and DOST-PCIEERD also see potential in this strategy to encourage partnerships between LGUs and the private sector.

Implementing pilot projects

Engaging in pilot projects is another pathway, according to respondents. For LGUs, this pathway enables them to access technology or system for free. Cauayan City LGU, for example, positions itself as a city lab to partners, inviting the private and public sectors to test their innovations in the city.

On the other hand, partners use this pathway to enhance their products or technology further. Some implement pilot projects and gather more experience and insights from there. Others use the LGU and public feedback to improve their products further. Their pilot projects with their partner LGUs serve as proof of concept, which they can use to market their technology.

Establishing smart city regional hubs or innovation hubs

For some LGUs, establishing regional hubs is an effective pathway for smart city initiatives. Through these hubs, they can learn from the best practices of their neighboring LGUs in terms of smart city initiatives, and duplication of efforts is avoided. LGUs and partners value the importance of establishing innovation hubs wherein they can develop people and technology through partnerships with universities, consequently creating jobs and sustaining smart city initiatives. Development organizations and NGAs see this as a strategy to promote regional development, providing frameworks to scale initiatives to other cities nationwide. These innovation hubs can also provide avenues wherein the growth of startups is encouraged through technical and funding support.

Development of customized systems

Most interviewed LGUs noted that their initiatives were borne out of specific issues their city faces and sometimes brought about by partnerships. Hence, these initiatives can be supply-driven, wherein technology innovators and producers create or customize their products or solutions for LGUs and NGAs, or demand-driven, wherein LGUs can specifically seek assistance and support from NGAs and private partners through formal channels.

Other pathways cited by the respondents were compliance with required certifications and policies related to permits and licensing, and application for funding through local or international grants or loans.

Recommendations

Participants were also asked about the strategies they would recommend addressing challenges to smart city development. Annex 17 describes the different recommendations from the interviews.

LGU-level recommendations

Information dissemination and feedback. Engaging the public and LGU staff is important for the successful implementation of smart city initiatives. According to the LGUs, they need people to grasp why they must comply with new policies or use certain applications. Some interviewees shared there has been some resistance among LGU staff during their ISO certification due to additional work required and among the public when there is new technology to be used. But after increasing understanding and appreciation of the reason behind those initiatives, uptake was hastened.

Information is shared through public meetings, publication material, and social media platforms. Aside from official emails and hotlines, social media platforms were important in getting public feedback due to their accessibility. Many LGUs collect feedback from the public through their official websites, social media pages, and even emails to improve their service delivery. LGUs also constantly seek ways to address the digital divide by providing equipment and reliable and accessible internet connections.

Private partners observed that good public engagement facilitates the smooth implementation of smart city initiatives, especially in projects involving infrastructure and public participation. One private partner shared that the information drive launched by its partner LGU to explain their project was quite helpful.

Partnership through formal agreements and ordinances. Respondents also highlighted the importance of establishing strong partnerships, especially with local universities, in capacitating the people required

to operate and sustain smart city projects. Volunteer organizations also ensure a prompt response, especially during accidents, fire, and disaster, as shared by an LGU respondent. Moreover, local partnerships provide context-specific solutions to public concerns. International partnerships also play an important role in developing smart cities in the country, and different NGAs and private partners can facilitate these.

Since partnerships are important in implementing smart city initiatives, these relationships must be secured and formalized. MOAs and contracts are considered legal and binding documents between different stakeholders. However, it is usually timebound and needs renewal. Many LGUs shared that issuing ordinances will ensure that the initiatives will be funded and sustained in the future. One of the participants pointed out that an ordinance is considered permanent compared to executive orders, which are only effective during the incumbent leader's term. From the perspective of some private partners, MOAs and other forms of agreements ensure the commitment of LGUs to the projects.

Capacity building. With the fast-paced technological development, continued capacity building is essential. LGUs reiterated that they need to identify a group of trained staff to operate and maintain these systems. Hence, many opt to institutionalize their ICT and planning departments and continue to seek training opportunities for continued capacity development. LGUs also ensure that MOAs and contracts have provisions on technology transfer and development of staff.

Develop smart city champions. Aside from technical capacity building, the smart city concept should also be imbibed among the LGUs. Many private partners highlighted the importance of smart city champions at the LGU level since it will open opportunities to engage with them. A business partner reiterated that "(t)here should be a mutual intent to do a smart city project," or the initiative will not prosper.

Consolidate systems or projects. LGUs are starting to look for ways to integrate systems and avoid duplication of existing initiatives. This will help them use their available resources and information, enabling informed decisionmaking and policymaking. One example is the case of Malabon City LGU, where a centralized database for social and health services is made available through a Malabon ID system. Some LGUs disclosed that they are also exploring options to integrate their

data systems in planning and financial management by establishing an ICT office.

Seek grants or loans. Considering the huge budgetary requirement to implement smart city projects, many LGUs and even private partners considered seeking grants and loans to augment funds for their initiatives. They usually apply for grants from international organizations and local funding agencies.

National-level solutions

Creation of a national roadmap or agenda. NGAs and private partners see the importance of developing a regional roadmap and national policies and guidelines to guide LGUs and private partners on what projects to prioritize. This will also ensure that proposed projects are aligned with the national development goals and prevent duplication. A national guideline will also standardize data collection and create a standard index where the development of cities can be assessed at the national level. Moreover, national policies crafted using the best practices in the country will allow cities to learn from other cities.

Improve monitoring and evaluation. Different stakeholders identified establishing better monitoring and evaluation of smart city initiatives as important, especially since some services will be devolved to them due to the Mandanas-Garcia Supreme Court Ruling. To this end, the DOST-PCIEERD highlighted the importance of having a national standard index that can help integrate smart city solutions and data at higher governance levels.

Provide grants and loans. NGAs should continue their existing programs that assist startups and LGUs to engage in projects that help address local issues. NGAs also play an important role in connecting these LGUs and startups to funding agencies abroad to encourage the continued development of smart city initiatives at the city level. Inevitably, this will encourage local research and development of technology and innovation.

Other solutions to specific challenges mentioned by respondents were the following: incentivize smart city innovators and those who will engage in implementing smart city projects; support research and development to keep up with the fast-paced technological development;

implementation of big projects by phases, especially projects involving infrastructure developments; and creation of wireless internet connection nationwide.

Conclusion

There is a lack of studies on whether Philippine cities are capable of undergoing the development required for smart city development. There is also a lack of literature on the experiences of Philippine cities toward becoming smart. This study enriches the literature by determining the drivers and extent of smart city development in the Philippines. Determining motivations and enablers is intended to validate the expectations of LGUs from smart city initiatives, ensuring that efforts are targeted to achieve what are believed to be possible outcomes of smart city development. Providing insights on the extent of smart city development supports the idea that cities are capable of employing such initiatives. Finally, recommendations about the roles of national and local governments in addressing challenges are provided to facilitate the development.

This study shows that the Philippines has started to tread the path toward building smart cities, and some Philippine cities exhibit preparedness for smart city development. The potential of having smart cities in the Philippines is apparent as interviews, even those in cities initially thought not to have a high level of implementation, have shown the motivation of both the public and private sectors to implement smart city initiatives. To take the discussion up a notch, LGUs have already implemented smart city initiatives. The Philippines, however, should have an operational strategic framework to ensure that smart cities are built up with coherence so that the initial phases of development will provide the building blocks for the next initiatives.

What drives Philippine LGUs toward the implementation of smart city initiatives?

In addressing the first policy question, motivations and enablers of smart city development were identified based on insights into the cases of interviewed LGUs. LGUs were generally found to be motivated by

the expected outcomes of smart city initiatives, and they have identified enablers aligned with those from reviewed literature.

The outcomes based on reviewed literature appear to be the motivations of stakeholders of smart city initiatives. The motivations of LGUs were consistent with the three outcomes (i.e., high quality of life, competitive economy, and sustainable environment) captured in the working definition. LGUs' desire to address pressing urban challenges has encouraged them to implement smart city initiatives. Motivation among LGUs to help each other adopt smart tools was also seen in some cases, potentially paving the way for development at a wider scale. Meanwhile, stakeholders aside from LGUs are also motivated to support smart city development, as evidenced by their involvement in numerous initiatives. NGAs and development organizations participate in such initiatives because of their respective mandates and objectives, and businesses provide support as part of their corporate social responsibility and to help foster a good economic environment. The alignment of motivations reflects the potential of aspiring smart cities to become successful.

Enablers of smart city development were identified during the interviews. Within LGUs, the presence of smart city champions, ICT department/staff, digitized data, and ICT infrastructure facilitate the adoption of smart city initiatives in cities. Smart city champions are leaders or staff who see the value and advocate using available technology to address the issues their city is facing. Leaders who are willing and committed to implement smart city initiatives help attract some partners. Government policies also encourage involvement. Additionally, stakeholder engagement is identified as an enabler in interviews with LGUs, as in reviewed literature and cases of international cities. In terms of financial sources, however, while cases of international cities and reviewed literature reflect high importance on PPP-enabled financing, more emphasis has been placed on getting financial support from international organizations and/or local funding agencies. Based on online resources and documents from the LGUs, financing from the internal budget is also a frequent mode used. There are also some biddings carried out. Insights regarding the enablers reflect potential actions that aspiring smart cities can take.

What is the extent of smart city development among Philippine cities?
In terms of extent, numerous smart city initiatives have already been implemented by cities in the Philippines across the infrastructure, data, and service phases of smart city development, and they are supported by NGA efforts. In the selected cities, there are generally more initiatives in the infrastructure phase. Initiatives include the installation of fiber optics and the provision of free Wi-Fi. Within the infrastructure phase, NGAs play an important role, providing support in increasing access to necessary infrastructure, including the internet, and implementing relevant programs such as the NBP. In the data phase, there are initiatives such as the development of data systems. Expected to support initiatives within the phase are policies under the Data Privacy Act and EO 2 (s. 2016) on which the FOI is based. Meanwhile, initiatives in the service phase include platforms enabling electronic transactions. Such initiatives within the phase are supported by policies, including those under the Ease of Doing Business and Efficient Government Service Delivery Act of 2018 (RA 11032). The discussions on the extent of smart city development signify that efforts at the local level are complemented by policies issued at the national level. The cases, however, lack a logical succession of phases from infrastructure to data to service. In some cases, numerous initiatives are under the infrastructure and service phases, while the data phase falls behind. This raises the question of whether the services offered are evidence-based and properly address constituents' needs.

Additional insights on the extent of smart city development in terms of relevant initiatives of interviewed LGUs were derived using the working definition. Generally, cities focus more on built infrastructure and civic and social domains. The main targets of efforts across the LGUs are to provide their constituents with a high quality of life. There are also generally more initiatives involving institutions, data, and information, while people and knowledge fall short in their respective categories of stakeholders and semiotics, respectively. The findings reflect similarities in the elements of smart city development adopted by the LGUs. They also reveal the factors that can still be explored in the journey to becoming smart cities.

How can the Philippine government facilitate the development of smart cities?

The path to becoming smart cities comes with challenges, risks, and disadvantages, which have to be addressed by the government. Issues have been established in this study; nevertheless, the government has the capacity to address the problems and facilitate smart city development.

Challenges encountered by interviewees in relation to smart city development include the lack of funding and infrastructure, especially considering that setting up ICT infrastructure and continuously upgrading systems require investments. Meanwhile, similar to some insights from reviewed literature, some interviewees find changes in administration or political uncertainty as a concern. Some private sector stakeholders relate changes in leadership to changes in priorities, threatening existing projects, especially those not yet institutionalized by an ordinance. Some interviewees think policies and standards to guide the implementation of smart city initiatives are still insufficient. It should be noted, nevertheless, that many of the interviewees did not mention using the PNS ISO 37122:2020 and the DOST Framework for Smart Sustainable Communities and Cities as references. The identified issue on policies and standards can be linked to another identified challenge: the lack of interoperability of data systems. In relation to data, some private sector partners and NGAs cited a lack of public trust in data management as the reason for the slow public uptake of smart city initiatives. Meanwhile, LGUs attributed slow uptake to the adjusting period for understanding and learning. Finally, low digital literacy was seen in some cases.

Although only a few interviewees associate risks and disadvantages with smart city development, these are nevertheless critical areas of concern. Issues concerning data privacy will become more prominent as smart city development increases, given the reliance of such growth on data availability. An interviewee also raised that technology might be used for political interests. There are other concerns about some smart city initiatives in the Philippines not mentioned during the interviews. This focus on smart city initiatives involving reclamation, such as those in Dumaguete and Manila. As with other reclamation projects, areas of concern include the potential environmental degradation and negative implications of such projects on the livelihood of fishermen. However, studies on estimating the net benefits or losses from implementing

reclamation projects for smart city development are lacking. Overall, the Philippine government should be on the lookout for pitfalls, given the risks and potential disadvantages associated with smart city development.

At the local level, identified pathways can help address some of the issues. For instance, LGUs have been conducting information dissemination activities to increase awareness of relevant projects, and feedback mechanisms have been made available. Likewise, there have been attempts to improve the digital literacy of LGU staff and constituents. Capacity building is carried out to increase human capital that would support smart city development. Pilot projects are being implemented, given foreseen benefits both in the public and private sectors. Meanwhile, ordinances, resolutions, and/or MOAs help ensure the sustainability of smart city initiatives and partnerships. There are also regional/innovation hubs being developed. Aspiring smart cities should assess whether they can also take such pathways.

NGAs, through their policies and programs, have the capacity to complement efforts at the local level in addressing the issues and supporting smart city development. Support from the NGAs has been mostly concentrated in the infrastructure and data phases. The PPP Center has been supporting some smart city initiatives under the PPP mode. The DICT facilitates connectivity, while the DOST-PCIEERD helps in capacity building for the development of technologies. Additionally, the NPC promotes and monitors data privacy. In the service phase, DILG and DICT support the implementation of the law on ease of doing business and efficient government service delivery. Furthermore, it is evident that despite some NGAs not having an established definition of "smart city", their programs and activities still support smart city initiatives. However, while government efforts are notable, additional pathways discussed in the following section can be taken to support the building of smart cities further.

Recommendations

Increasing the readiness of Philippine cities for smart city development will involve various government offices. The presence of enablers and already existing smart city initiatives have signified preparedness

for such a development; however, there are unaddressed gaps in the smart city agenda in the Philippines. The national government can help address the gaps by providing additional support in developing policies and standards to improve data flow, promoting technology and innovation-powered cities, and ensuring transparency and accountability in implementing smart city initiatives.

The Philippines should consider branding its cities as smart. The lack of consensus on the definition of "smart city" is enough reason for the national and local governments to clarify the brand well and the outcomes that can result from implementing smart city initiatives. Aside from "smart city", the terms associated with similar initiatives include "digital city" and "intelligent city". The rising number of articles on smart city should be one ground for deciding whether to shift the term used, provided that the involved initiatives can be categorized as smart. Establishing a brand for technology and innovation-powered Philippine cities can unlock opportunities to gain additional investments for government projects. The brand should be echoed by complementary policies to reflect the commitment to realizing the vision.

Should the Philippines decide to pursue applicable branding initiatives as smart, special roles can be given to the DOST-PCIEERD and DILG to establish a good brand. The DOST-PCIEERD may take the lead, given its mandate. It can enhance the DOST Framework for Smart Sustainable Communities and Cities and leverage its experience in linking smart city stakeholders with LGUs to implement additional support strategies. Meanwhile, the DILG can promote and monitor the adoption of the framework and gauge smart city development among Philippine cities based on smart city indicators under PNS ISO 37122:2020. Information dissemination campaigns should be held at the national level to increase the understanding of the smart city concept and vision. The campaigns should also serve as venues for the government to increase people's participation in building smart cities, an aspect seemingly lacking in some initiatives. This can help improve public uptake of initiatives to be implemented. Furthermore, the DILG can implement an accreditation system following the PNS and the framework to incentivize cities to adopt the smart city concept. The DILG can then be equipped with data and evidence when showcasing Philippine cities.

The vision should be accompanied by a plan on how the outcomes will be attained. Likewise, the logical succession of the phases of smart city development should be incorporated into the plan. The infrastructure phase should come first, followed by the data phase and the service phase. Veering away from this succession could eventually bring rise to challenges, such as failure to address constituents' needs properly and losing out on opportunities to engage with stakeholders who require particular developments in preceding phases of smart city development. Furthermore, issues among the initiatives within each phase at the national level (e.g., NBP, Free Wi-Fi for All Project) should be resolved to increase the facilitation of smart city development.

The identified enablers can serve as indicators of readiness for smart city development. While PNS ISO 37122:2020 already provides smart city indicators, measures reflecting cities' readiness for smart city development will provide insights into the capacity of LGUs to implement smart city initiatives. Based on the discussed enablers, indicators of the readiness for smart city development can include the following: (1) the presence of smart city champions; (2) the presence of ICT departments or personnel; (3) the number of completed projects supported by ordinances, resolutions, and/or MOAs involving businesses, development organizations, and/or NGAs; (4) the number of constituents with access to the internet; and (5) availability of digitized data. These suggested indicators are expected to help LGUs prepare for smart city development. The DOST-PCIEERD can also use them in assessing aspiring partner LGUs.

No smart city is going to be built without partnerships. Stakeholder engagement is valued not only by aspiring smart cities in the Philippines but also those in other countries. LGUs should build relationships with the public and private sectors. These sectors include the academe, development organizations, businesses, other LGUs, the national government, and constituents. LGUs should know what technologies are available and the support services offered at the national level. LGUs can even pilot the implementation of initiatives through engagements to see which ones are worthwhile to utilize at a wider scale in the long term.

Accountability is one of the themes that can enhance the DOST Framework for Smart Sustainable Communities and Cities. The agenda

in developing a smart city should include increasing the capacity of people and institutions to monitor progress in government projects, given the availability of technologies and data. Smart city development comes with a responsibility among LGUs to be transparent to their constituents. LGUs should not only collect data from the people but also provide data to them. Such data sharing can generate innovation that would not have otherwise been developed. The DILG can mandate LGUs to provide nonconfidential data involving their projects on a platform easily accessible by their constituents.

The DICT and NPC can issue policies and standards on developing data repositories and application programming interfaces for aspiring smart cities. Aspiring smart cities are not required to be equipped with only one technology to address all urbanization challenges to meet their objectives and ensure interoperability. However, they need technologies to transfer data into common but secure data repositories to enable faster, evidence-based decisionmaking. Following relevant standards will allow LGUs to efficiently use data in policy decisions while assuring respective constituents that the data provided are securely managed.

Risk mitigation strategies should be laid out in the framework of smart cities. The assurance from the government that it will not dismiss the potential negative impacts of smart city projects on the environment and livelihood must be ensured. For instance, the PPP Center can provide guidance in the conduct of feasibility studies and cost-benefit analyses for PPP projects. Meanwhile, given the emphasis of the DOST Framework for Smart Sustainable Communities and Cities on the importance of data and evidence in smart city development, ways of ensuring data protection should be discussed. Given NPC's mandate and expertise, the agency can guide in ensuring data privacy in smart city projects, including those involving private sector partners. The presence of a comprehensive approach to data protection and its proper implementation in smart cities will encourage constituents to take on their roles to provide data to the government and its partners willingly. Furthermore, similar to some international city governments, LGUs in the Philippines should be transparent in handling data for various involved activities.

Smart cities are not meant to stand alone but are built and maintained by numerous stakeholders besides LGUs and NGAs. The

constituents should have venues to raise concerns, ideas, and feedback. After all, their needs are at the core of what smart cities should address. LGUs can work with the DOST-PCIEERD in conducting a gap assessment of technologies and needs, and the academe can be involved in addressing the gap. Support of development organizations in capacitating LGUs should be sought. Available technologies offered by businesses should also be assessed on their potential contribution to smart city development and relevant costs.

In terms of financing, LGUs can work on expanding the range of options. The conduct of PPP smart city projects should be explored more as an additional option, given the emphasis placed on its potential in the reviewed literature and cases of international cities. LGUs can work with the PPP Center to build their capacity to implement PPP projects and conduct feasibility studies. Ultimately, engagements with stakeholders in smart city initiatives, including those implemented by the private sector, should be supported by ordinances, resolutions, and/or MOAs to help ensure sustainability.

Smart cities have the potential to address urban challenges, but the findings of this study show the amount of work needed to be carried out before the Philippines can establish these cities. Although LGUs can already implement smart city initiatives, participation from government offices at the national level is essential. The national government must guide and support LGUs in addressing the challenges to smart city development to ensure that the potential of smart city initiatives will not be limited.

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Annexes

Annex 1. Cauayan City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
E-tricycle prototypes and Charging in Minutes station	• E-tricycle prototypes; some models with solar panel on roof • Charging station	• Infrastructure	• Process • Translate	• Built infrastructure • Quality environment	• Data • Information	• Institutions	• Sustainable environment
Hybrid electric road train	• 4 air-conditioned interlinked cabins for maximum of 200 passengers	• Infrastructure	• Process • Translate	• Built infrastructure • Quality environment	• Data • Information	• Institutions	• Sustainable environment
E-scooter project	• E-scooters with app for control and global positioning system for tracking	• Infrastructure	• Process • Sense	• Built infrastructure • Quality environment	• Data • Information	• People • Institutions	• Sustainable environment
PATURO: Platform for Assessment and Tracking of Urbanization-Related Opportunities	• Data hub • Smart Index • Sandbox	• Data	• Sense • Monitor • Process • Communicate	• Built infrastructure	• Data • Information • Knowledge	• People • Institutions	• Sustainable environment
Wi-Fi routers	• Wi-Fi routers for free	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Fiber optics	• Installation of fiber optics	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life

Annex 1 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Cell sites and cellular network system	• Installation of cell sites and/or expansion of cellular network system • 4G/LTE	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Wi-Fi	• Obtainment of Wi-Fi services	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Barangay centralized Wi-Fi network	• Enables messaging and file sharing from LGU to barangay, barangay to barangay, and barangay to LGU via 5Ghz radio signal and high sector antenna • Extranet • LAN Messenger	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• Institutions	• Competitive economy
QR code for barangay constituents	• Intended for household profiling that can be used for relief assistance distribution	• Data	• Sense • Process Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life
Cauayan City App	• Enables transactions related to e-government, e-bills, e-commerce, e-services, and e-wallet	• Service	• Process • Translate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life

Annex 1 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Cauayan City Identification Card	• Version 1 - simple ID • Version 2 - ATM-enabled • Version 3 - Mastercard-enabled	• Service	• Process • Translate • Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life
Juan Time campaign	• Synchronization of time across devices • Provides weather updates	• Infrastructure	• Communicate	• Civic and social	• Data • Information	• Institutions	• Competitive economy
Kiosk machines	• Payment of bills at kiosk machines	• Service	• Process • Translate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life
Police drones	• To keep constituents safe, capture criminals, and implement lockdown restrictions	• Service	• Sense • Process • Communicate	• Safety and security	• Data • Information	• People • Insitutions	• High quality of life
Digital Twin	• From drone photos to 3D map of the landscape • AI for damage estimation	• Data	• Sense • Monitor • Process Communicate	• Safety and security	• Data • Information • Knowledge	• People • Institutions	• High quality of life • Sustainable environment
Waste-to-energy plant	• Generate energy using waste products from Cagayan Valley	• Infrastructure	• Process • Translate	• Quality environment	• Data • Information	• Institutions	• Sustainable environment

Annex 1 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Aquaponics	• IoT-based aquaponics with integrated sensors monitoring dissolved oxygen, humidity, water level, and temperature	• Infrastructure	• Sense • Monitor • Process	• Quality environment • Industry and innovation	• Data • Information • Knowledge	• Institutions	• Competitive economy • Quality environment
Investment website	• Presents investment opportunities and incentive package	• Data	• Communicate	• Industry and innovation	• Data • Information	• Institutions	• Competitive economy
Water quality testing laboratory	• Tests the quality of water	• Infrastructure	• Sense • Process • Communicate	• Health and well-being	• Data • Information • Knowledge	• Institutions	• High quality of life • Sustainable environment
No QR Code, No Entry Policy	• Requirement to register for unique QR code to facilitate contact tracing	• Service	• Sense • Monitor • Process • Communicate	• Health and well-being	• Data • Information • Knowledge	• People • Institutions	• High quality of life
RxBox	• Measures heart rate, oxygen saturation, temperature, etc. • Distributed to geographically isolated and disadvantaged areas	• Infrastructure	• Sense • Process • Communicate	• Health and well-being	• Data • Information • Knowledge	• People • Institutions	• High quality of life

Annex 1 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Cauayan City Care COVID-19 Consult	• Telemedicine	• Infrastructure	• Process • Communicate	• Health and well-being	• Data • Information	• People • Institutions	• High quality of life
Smarter Dengue Early Warning System	• Dengue vector surveillance • Smarter Dengue Early Warning System App • Disease mapping on 3D model using AI • Dengue information mapping	• Service	• Monitor • Process • Communicate	• Health and well-being	• Data • Information • Knowledge	• People • Institutions	• High quality of life

4G = fourth generation; LTE = long-term evolution; LGU = local government unit; IoT = Internet of Things; 3D = three dimensional; AI = artificial intelligence; LAN = local area network; Ghz = gigahertz; QR = quick response; ATM = automated teller machine; COVID-19 = coronavirus disease 2019
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 2. Cauayan City initiatives' administrative details

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
E-tricycle prototypes and Charging in Minutes station	• DOST • Isabela State University • University of the Philippines Diliman • DOST-PCIEERD • Electronics Industries Association of the Philippines Inc. • Manufacturers and sellers of e-trikes and e-bikes	• Commercial viability supported through financial aid from DOST	• 2017: Launch of e-charging station and parade of prototype models for e-trikes	• 2 installed chargers	
Hybrid electric road train	• DOST-Metals Industry Research and Development Center	• From DOST	• 2019: Launch and turnover ceremony	• 560 catered passengers (students, senior citizens, PWDs, and frontliners)	
E-scooter project	• DOST • Isabela State University • University of the • Philippines-Electrical and Electronics Engineering Institute • Filgenius	• From DOST	• 2020: Launch and turnover ceremony	• 7 e-scooters	• MOA with DOST, Isabela State University, UP-Electrical and Electronics Engineering Institute, and Filgenius
PATURO: Platform for Assessment and Tracking of Urbanization-Related Opportunities	• DOST-PCIEERD • Asian Institute of Management • Isabela State University	• From DOST-PCIEERD	• 2020: Launch		

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Wi-Fi routers			• 2014: Distribution to 65 barangays	• 65 barangays equipped with free Wi-Fi routers	
Fiber optics	• PLDT Inc.		• 2017: Installed fiber optics		
Cell sites and cellular network system	• Smart Communications Inc.		• 2005–2019: Approval of resolutions on installation of cell sites and/or expansion of cellular network system		• Resolutions 2005-2-049, 2005-2-104, 2012-4-005, 2012-4-006, 2012-4-102, 2019-7-162, 2019-7-163, 2019-7-164, 2019-7-165, and 2019-7-166
Wi-Fi	• Smart Communications Inc.		• 2019: Approval of resolution		• Resolution 2019-6-070
Barangay centralized Wi-Fi network				• 65 barangays equipped with communication network and internet	
QR code for barangay constituents				• Barangay Cabaruan constituents with QR codes - Population of 8,244	

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Cauayan City App	• Multisys Technologies Corporation		• 2014: Launch of 1st version • 2019: Launch of 2nd version	• Total downloads from App Store as of November 10, 2020: - China: 3,179 - Philippines: 832 - US: 89 - Japan: 74 - Singapore: 79 • Total downloads from Play Store as of November 10, 2020: - Philippines: 18,224 - Saudi Arabia: 126 - US: 98 - Canada: 66 - Taiwan: 37 - India: 22 - South Korea: 20 - Italy: 18 - Japan: 16 - Brazil: 13	

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Cauayan City Identification Card	• GCash		• 2014: Launch of Version 1 • 2015: Launch of Version 2 • 2018: Launch of Version 3	• 5,000 IDs distributed to government employees and constituents	
Juan Time Campaign	• DOST	• From DOST	• 2014: Launch	• 65 LEDs for Juan Time and disaster information distributed	
Kiosk machines					
Police drones			• 2019: Barangay Cabauran Police became equipped with drones	• 3 drones deployed for monitoring of constituents during lockdown	

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Digital Twin	• Graffiquo • United Cities Asia	• Donated by Graffiquo	• 2020: Integrated digital twin system was created	• Captured in 2 days: 0.5 square kilometer of waterfronts • 3D landscape models • Estimated 7,724 families for evacuation, PHP 22 million damages to crops, and PHP 550 million damages to infrastructure	
Waste-to-energy plant	• Other Metro Cauayan and Isabela LGUs • Clean World Sustainable Solutions Inc.		• 2019: Launch and MOA signing		• MOA with other Metro Cauayan and Isabela LGUs, and Clean World Sustainable Solutions Inc.
Aquaponics	• Temasek Polytechnic University • Isabela State University		• 2019: Launch and turnover ceremony	• 160 households in Sitio Manalpaac given livelihood assistance	

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Investment website					
Water quality testing laboratory	• DOST • Isabela State University		• 2017: Resolution approved		• Resolution 2017-6-122: Resolution authorizing the Honorable City Mayor Bernard Faustino Dy to enter into a memorandum of agreement with the DOST and Isabela State University for the establishment of a water quality testing laboratory in support to smarter cities
No QR Code, No Entry Policy	• Nspire Inc. • AJ Enterprises				

Annex 2 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
RxBox	• DOST • Ionics EMS Inc.	• Donated by Ionics EMS Inc.	• 2015: Turnover		
Cauayan City Care COVID-19 Consult	• Isabela State University • DOST • CHED • Dynamic Outsource Solutions Inc.		• 2021: Launch		
Smarter Dengue Early Warning System					

DOST = Department of Science and Technology; PCIEERD = Philippine Council for Industry, Energy and Emerging Technology Research and Development; PWDs = persons with disability; MOA = memorandum of agreement; ID = identity document; LED = light emitting diode; 3D = three dimensional; PHP = Philippine peso; CHED = Commission on Higher Education; UP = University of the Philippines

Source: Authors' summary based on documents from interviewees and/or online resources

Annex 3. Tuguegarao City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Digital Twin	• Conversion of drone photos to 3D model	• Data	• Sense • Monitor • Process • Communicate	• Safety and security	• Data • Information • Knowledge	• People • Institutions	• High quality of life • Sustainable environment
Command center	• Real-time monitoring center • CCTV	• Data	• Sense • Process • Communicate	• Safety and security	• Data • Information	• People • Institutions	• High quality of life
Free direct internet	• Direct internet enabling connection between offices for video application, voice, and data needs	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• Institutions	• High quality of life
Tuguegarao Government Portal	• Online government services (travel pass application, checkpoint registration, QR card for nonresidents, online payment and QR for residents and nonresidents, and vaccination registration)	• Service	• Sense • Monitor • Process • Translate • Communicate	• Civic and social	• Data • Information • Knowledge	• People • Institutions	• High quality of life
MyCure System	• Online medical consultations	• Infrastructure	• Process • Communicate	• Health and well-being	• Data • Information	• People • Institutions	• High quality of life

3D = three dimensional; CCTV = closed-circuit television; QR = quick response
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 4. Tuguegarao City initiatives' administrative details

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Digital Twin	• Cauayan City LGU				
Command center	• Philippine National Police • Bureau of Fire Protection				
Free direct internet	• Globe Business	• From Globe Business			
Tuguegarao Government Portal					
MyCure System	• DOST				

LGU = local government unit; DOST = Department of Science and Technology
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 5. San Fernando City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Command and control center	• Telemetry for flood monitoring • LED information board • Communication tower • 360-degree thermal camera • Video analytics • License plate recognition • Facial recognition • Body cameras • Public address system	• Service	• Sense • Process • Translate • Communicate	• Built infrastructure • Safety and security	• Data • Information • Knowledge	• People • Institutions	• High quality of life
Free Wi-Fi in city hall and old public market	• Fiber-powered Wi-Fi in city hall and old public market	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Free Wi-Fi in public schools	• Wi-Fi for selected public schools	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Smart City Phase II Program	• Integration of CCTV features • Fiber optic cabling • Other improvements in infrastructure and equipment	• Infrastructure	• Sense • Process • Communicate	• Built infrastructure • Safety and security	• Data • Information	• People • Institutions	• High quality of life

Annex 5 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Solar panels	• Renewable energy source	• Infrastructure	• Sense • Process	• Quality environment	• Data • Information	• Institutions	• Sustainable environment
Online business transactions	• Online platform for business permit transactions and payment of business taxes • Option for delivery of business permits	• Service	• Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	• Competitive economy
Integrated/ centralized systems for interoffice transactions	• Development of applications and integrated/ centralized systems to expand linkage of interoffice transactions • Unified barangay business clearance • Barangay building clearance	• Infrastructure	• Process • Communicate	• Civic and social	• Data • Information	• Institutions	• High quality of life

LED = light emitting diode; CCTV = closed-circuit television
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 6. San Fernando City initiatives' administrative details

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Command and control center		• PHP 220 million from 2018 LGU savings and business sector	• 2020: Inauguration	• 110 bullet cameras • 15 pan-tilt-zoom cameras • Additional 115 CCTV • Additional 3 LED boards • Additional 10 workstations • Additional 26 video walls	
Free Wi-Fi in city hall and old public market	• Smart Communications, Inc.	• Donation from Smart Communications Inc.	• 2019: Signing of MOA		• MOA with Smart Communications Inc.
Free Wi-Fi in public schools				• 9 Early Childhood Care and Development Centers	
Smart City Phase II Program technologies	• Land Bank of the Philippines	• Loan from Land Bank of the Philippines • 2021 Annual Investment Program: PHP 100 Million	• 2021: Allotment in Annual Investment Program		
Solar panels					

Annex 6 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Online business transactions	• 2Go Express Inc.		• 2018: Signing of MOA	• Issuance of 11 new business permits • Renewal of 3 business permits	• MOA with 2Go Express Inc. under Resolution 2018-024
Integrated/centralized systems for interoffice transactions				• Implementation of Unified Barangay Business/Building Clearance: Renewal - 4,532 applicants; New - 745 • 2 systems developed for the linking of some government units • In-house development of online application of building clearance: 10% completion - data gathering stage	

PHP = Philippine peso; LGU = local government unit; LED = light emitting diode; CCTV = closed-circuit television; MOA = memorandum of agreement
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 7. Malabon City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
CCTV cameras	• CCTV cameras for emergency monitoring and response	• Data	• Sense • Process • Communicate	• Safety and security	• Data • Information	• People • Institutions	• High quality of life
Mobile connectivity	• 4G	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Free Wi-Fi	• Under Smart Barangay Connect Program aided by PLDT's fiber infrastructure	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Contact tracing app	• Application with QR code technology integrated into City Health monitoring system	• Service	• Sense • Monitor • Process • Communicate	• Health and well-being	• Data • Information • Knowledge	• People • Institutions	• High quality of life
Computerization of tax collection data and transactions	• Computerization in revenue-generating departments • GIS	• Service	• Process • Communicate	• Civic and social	• Data • Information • Knowledge	• People • Institutions	• High quality of life
Online payment services system	• Online payment services for government transactions	• Service	• Process • Translate • Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life

CCTV = closed-circuit television; 4G = fourth generation; QR = quick response; GIS = geographic information system
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 8. Malabon City initiatives' administrative details

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
CCTV cameras		• PHP 9,985,000.00: internal budget	• 2017: Bid opening		
Mobile connectivity	• Globe			• 6 new cell sites • 101 upgraded sites	
Free Wi-Fi	• Smart Communications Inc. • PLDT Inc.	• From Smart Communications Inc.			
Contact tracing app					
Computerization of tax collection data and transactions		• PHP 3.8 million: internal budget			
Online payment services system	• IB Solutions IBS Worldwide Corporation		• 2020: Contract with IB Solutions IBS Worldwide Corporation signed		

PHP = Philippine peso; CCTV = closed-circuit television;
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 9. Mandaue City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Guardian Emergency Response System	• Mobile application for reporting of incidents or requesting assistance • Software for dispatch and deployment	• Service	• Process • Communicate	• Safety and security	• Data • Information	• People • Institutions	• High quality of life
Traffic management system	• Traffic lights • Digital clocks • CCTV and high-definition cameras • LED streetlights	• Data	• Sense • Process • Translate • Communicate	• Safety and security • Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Internet	• Fiber broadband connection	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
Electronic business permit and licensing system	• Online processing of business permits with QR code and a security sticker	• Service	• Sense • Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	• Competitive economy

Annex 9 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Purok database system	• Database per purok to address pandemic	• Data	• Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life
Low carbon city	• Green Building Program • Solid waste management technologies • Modeling of Urban Heat Islands in Philippine Cities (Project GUHeat) • Biodegradable waste shredder • Rotary drum composter	• Infrastructure	• Sense • Monitor • Process • Translate • Communicate	• Quality environment	• Data • Information • Knowledge	• People • Institutions	• Sustainable environment

CCTV = closed-circuit television; LED = light emitting diode; QR = quick response
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 10. Mandaue City initiatives' administrative details

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Guardian Emergency Response System	• Sugbotek Inc.	• Free application provided by Sugbotek Inc.	• 2018: Signing of MOA		• MOA with Sugbotek Inc.
Traffic management system	• Dyna-Tech • HUALU E-Cloud	• Internal budget - PHP 79 million for traffic equipment with high-definition cameras and digital clocks in all of the city's 13 major intersections - PHP 5 million for traffic lights • Total budget for street lighting in 2021 Annual Investment Program - MOOE: PHP 13,706,005	• 1990s: Obtained CCTV cameras and sensors • 2013: Installed high-definition cameras and digital clocks • 2016: Approval of ordinance on no contact apprehension • 2019: Signing of Proof of Concept Agreement with Dyna-Tech and HUALU E-cloud • 2021: Budget for street lighting allotted in Annual Investment Program	• 13 major intersections with digital clocks and high-definition cameras	• Ordinance 14-2016-1110: An ordinance authorizing no contact apprehension for traffic violations in the City of Mandaue • Proof of Concept Agreement with Dyna-Tech and HUALU E-cloud to assess the transportation system

Annex 10 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Internet	• Converge		• 2021: Installation		
Electronic business permit and licensing system	• DICT		• 2021: Launch		
Purok Database System		• Total budget for Purok Database System in Response to the Pandemic - (General Fund) capital outlay: PHP 12 million	• 2021: Budget for Purok Database System in Response to the Pandemic allotted in Annual Investment Program		

Annex 10 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Low carbon city	• APEC • ALMEC Corporation • Ernst & Young Advisory Co. Ltd. • Michi Creative City Designers Inc. • Guun • Cafe-i • University of the Philippines Training Center for Applied Geodesy and Photogrammetry • DENR-EMB • Philippine Green Building Council • Vivant Foundation • Mandaue Chamber of Commerce and Industry	• Total budget for Climate Change Adaption and Environment Protection in 2021 Annual Investment Program - (General Fund) MOOE: PHP 500,000 • Total budget for Solid Waste Management Activities - (General Fund) MOOE: PHP 9,500,000 • Total budget for solid waste management initiatives - Expenditures in 2018: PHP 286,629,222.50 - Budget in 2019: PHP 301,894,036.25 • Biodegradable waste shredder and rotary drum composter from DENR-EMB • Bike stations financed by Vivant Foundation	• 2015: Approval of green building ordinance • 2017: Publication of final report on APEC LCMT Project Phase 6: Feasibility study for Mandaue City • 2021: Budget for climate change adaption and environment protection allotted in Annual Investment Program • 2021: Budget for solid waste management activities allotted in Annual Investment Program • 2021: DENR-EMB donated biodegradable waste shredder and rotary drum composter • 2021: Signing of tripartite MOA with Vivant Foundation and Mandaue Chamber of Commerce and Industry for the bike repair stations	• BERDE certification • 5 barangays with recyclables storage and composting facility • 13 units of rotary drum composter, biodegradable waste shredder, solar-powered 4G network camera kit • 1 bike repair station	• Ordinance 13-2015-1047: The Green Building Ordinance of Mandaue City • MOA with DENR-EMB • Tripartite MOA with Vivant Foundation and Mandaue Chamber of Commerce and Industry

MOA = memorandum of agreement; MOOE = maintenance and other operating expenses; PHP = Philippine peso; APEC = Asia-Pacific Economic Cooperation; DENR-EMB = Department of Environment and Natural Resources-Environmental Management Bureau; CCTV = closed-circuit television; DICT = Department of Information and Communications Technology; LCMT = Low Carbon Model Town; 4G = fourth generation
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 11. Tagum City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Revenue Administration and Mobilization Program	• Automated and integrated management system - Real Property Tax Administration System - Electronic Business Permit and License System - Other revenue generating system - Economic Enterprise System - Integrated Financial Management System - Human Resource and Management System - Executive System - Other Systems - Document Tracking System Web-based • Customizable for issuance of electronic official receipts • GIS	• Infrastructure	• Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life • Competitive economy
Integrated Systems Digital Network and Private Automatic Branch Exchange for City Trunkline Services	• IP telephones and a centralized trunkline	• Infrastructure	• Process • Translate • Communicate	• Civic and social	• Data • Information	• People • Institutions	• High quality of life

Annex 11 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Use of quad media	• Television • Radio • Print media • Social media	• Data	• Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	High quality of life
LED walls	• LED walls for information dissemination	• Data	• Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	High quality of life
Traffic signalization system and no contact apprehension	• Installation of traffic lights in priority junctions • Traffic surveillance cameras • Monitoring of traffic violations using figures and summaries of traffic violations (beating the red light, counterflowing, obstruction to pedestrian crossing, obstruction to double yellow lane, illegal parking, disregarding traffic signal, loading/unloading, illegal U-turn, obstruction to yellow box, obstruction to right lane, driving on sidewalk) in various areas	• Data	• Sense • Process • Translate • Communicate	• Built infrastructure • Safety and security	• Data • Information	• People • Institutions	High quality of life

Annex 11 *(continued)*

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
Smart street lighting	• Solar-powered streetlights along barangay roads	• Infrastructure	• Sense • Process • Translate	• Built infrastructure • Safety and security	• Data • Information	• Institutions	• Sustainable environment
Internet	• P2P Internet Tower	• Infrastructure	• Process • Communicate	• Built infrastructure	• Data • Information	• People • Institutions	• High quality of life
EURO 4-compliant heavy equipment and vehicles	• Equipment and vehicles for reduced greenhouse gas emissions	• Infrastructure	• Process • Translate	• Built infrastructure • Quality environment	• Data • Information	• Institutions	• High quality of life Sustainable environment
Tagum City Waste-to-Energy Plant Project	• Transformation of waste to energy	• Infrastructure	• Process • Translate	• Quality environment	• Data • Information	• Institutions	• Sustainable environment
e-Center	• Station for technology empowerment • Computers • Internet service	• Infrastructure	• Process • Communicate	• Industry and innovation	• Data • Information	• People • Institutions	• Competitive economy

GIS = geographic information system; IP = internet protocol; LED = light-emitting diode; P2P = point-to-point
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 12. Tagum City initiatives' administrative details

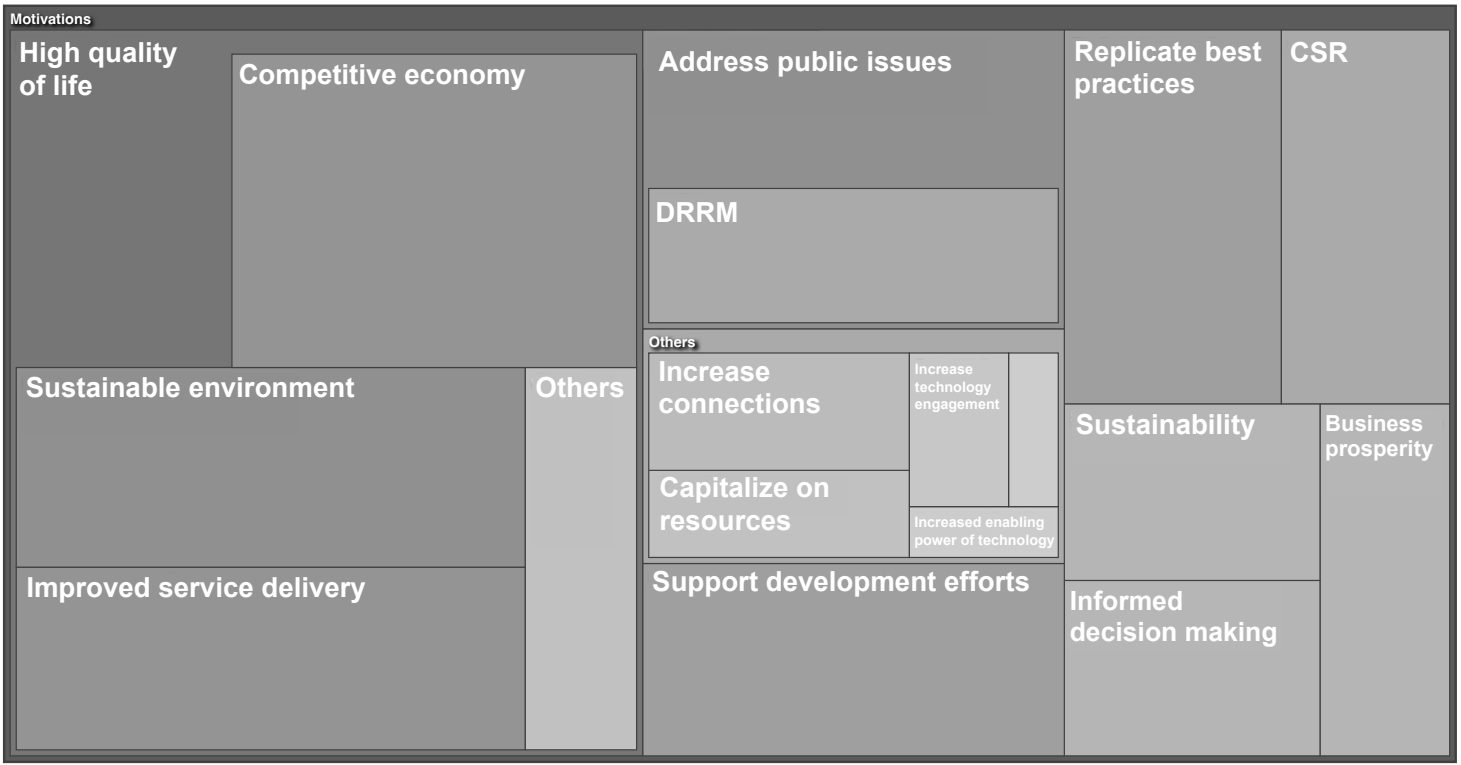
Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Revenue Administration and Mobilization Program	• DBP	• Loan from DBP: PHP 90 million pesos	• Under bidding process • Target Implementation: 2022 Q1		
Integrated Systems Digital Network and Private Automatic Branch Exchange for City Trunkline Services		• Loan • One-time investment: PHP 24 million • Additional PHP 6 million for improvement of the command and control center	• 2016: Implementation	• Still operating • Monthly record of callers, numbers, and purpose	
Use of quad media		• Internal budget	• 2014: Implementation		
LED walls				• Operational in 2 areas in city hall • Record details of announcements posted	
Traffic signalization system and no contact apprehension	• DBP • Traffic Supplies and Construction Corporation	• Loan from DBP: PHP 60 million • Design and build scheme	• 2018: Phase I implementation • 2020: Phase II implementation	• 10 intersections covered by system • Traffic surveillance monthly reports	

Annex 12 *(continued)*

Initiative	Partner	Finance	Timeline	Output	Ordinance/Resolution/ Memorandum
Smart street lighting		• 1st Phase (13 units): PHP 60,000 • For 2022, the Electrification Program has proposed amount of PHP 226,040,000 in AIP	• 2021 and onwards: implementation		
Internet	• DepEd	• Financed by Special Education Fund			
EURO 4-compliant heavy equipment and vehicles	• DBP	• Loan from DBP • PHP 26,537,777.77: Heavy equipment of City Engineer's Office • PHP 27,588,298.32: Sanitary Landfill Heavy Equipment	• 2021 onwards: Implementation	• EURO 4-compliant heavy equipment	
Tagum City Waste-to-Energy Plant Project	• Global Green International Energy Philippines Inc.	• PHP 757.61 million	• Under preconstruction		
e-Center	• DICT		• 2018: Launch		

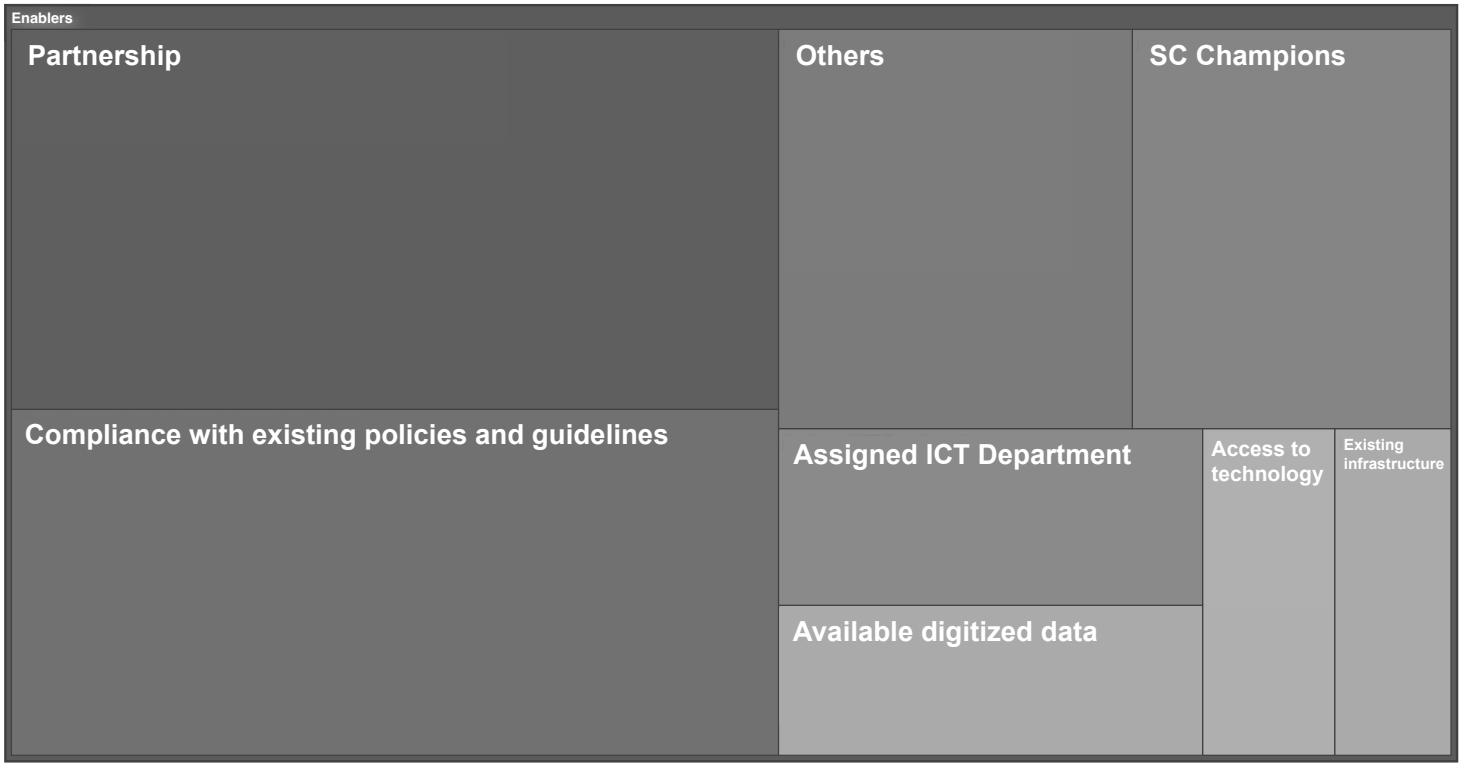
DBP = Development Bank of the Philippines; PHP = Philippine peso; DICT = Department of Information and Communications Technology; Q = quarter; LED = light-emitting diode; AIP = Annual Implementation Plan; DepEd = Department of Education
Source: Authors' summary based on documents from interviewees and/or online resources

Annex 13. Summary of themes for motivations for smart city engagements



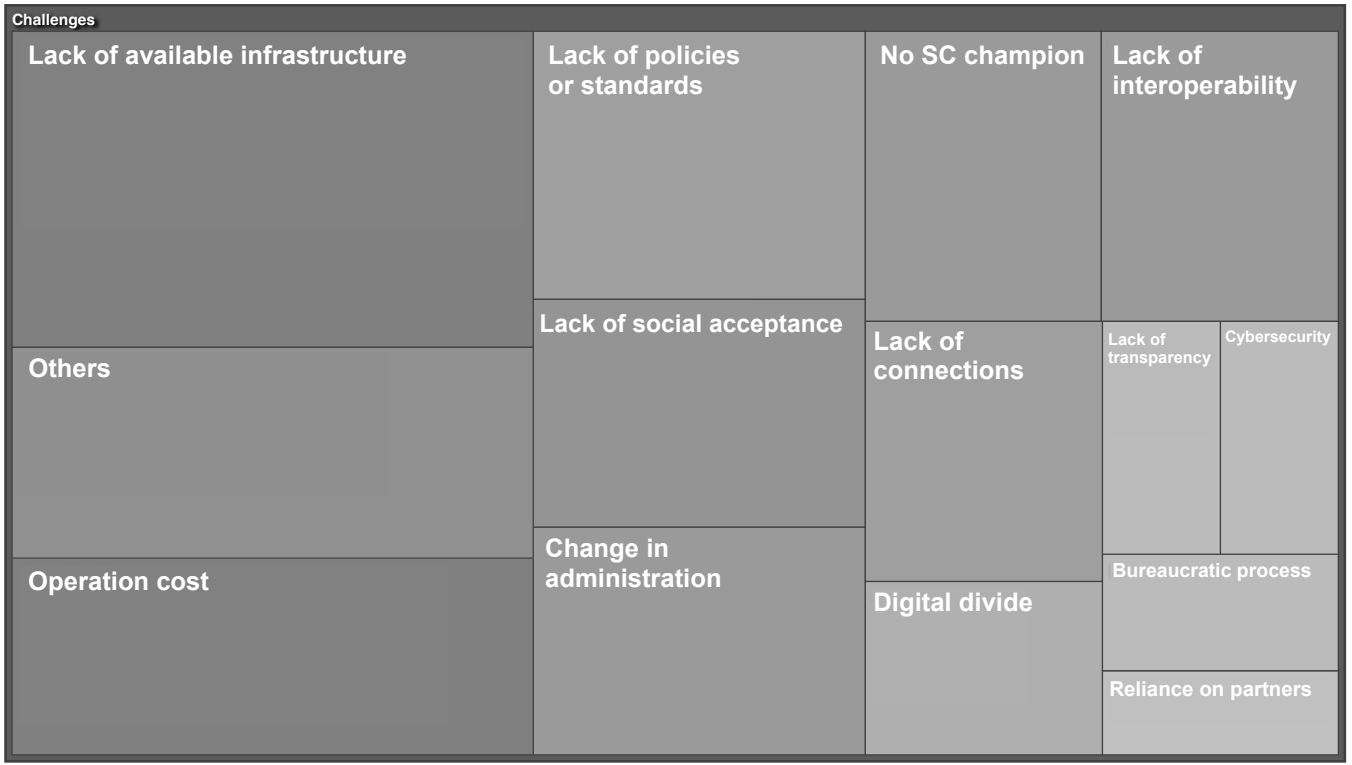
CSR = corporate social responsibility; DRRM = disaster risk reduction and management
Source: Authors' illustration

Annex 14. Summary of themes for enablers based on interview responses



SC = smart city; ICT = information and communications technology
Source: Authors' illustration

Annex 15. Summary of themes for challenges from interviews

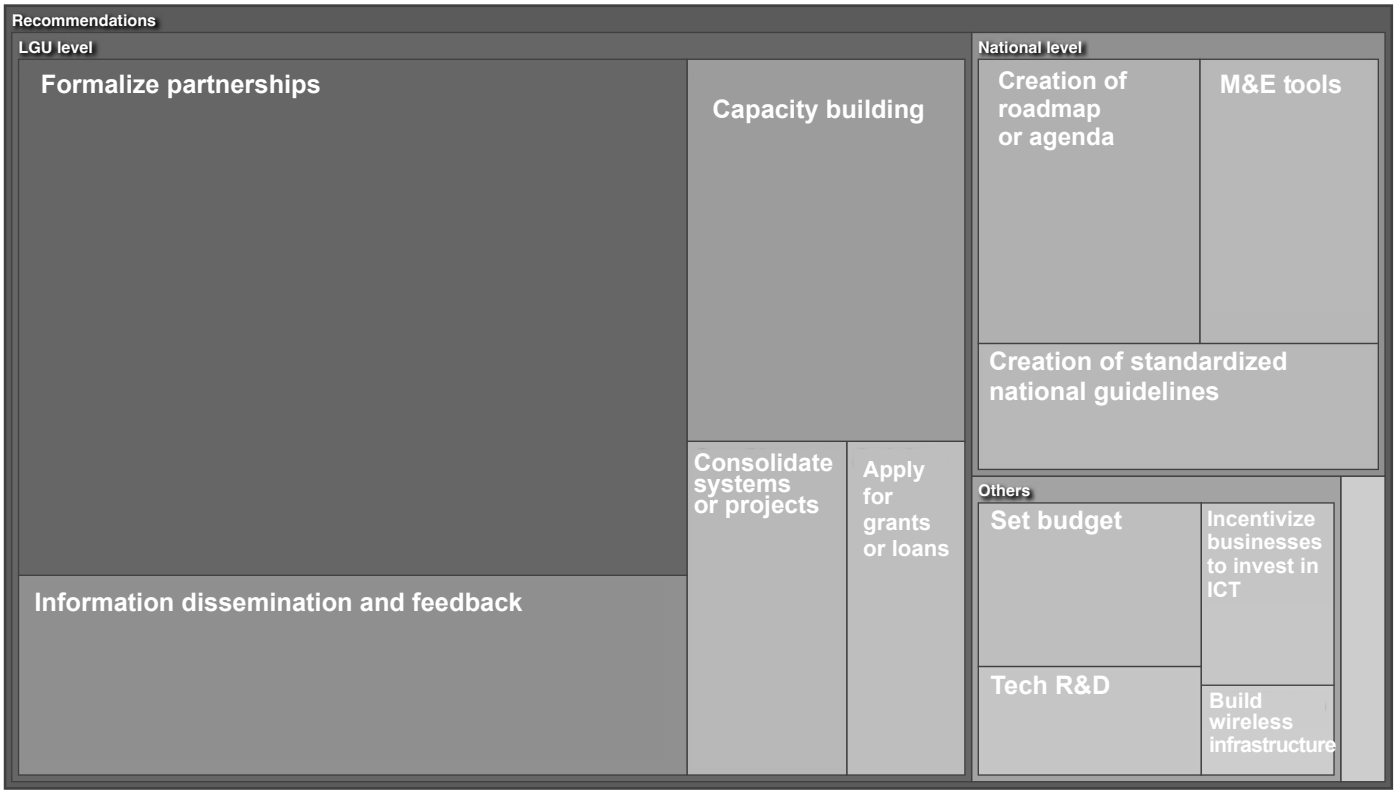


SC = smart city
Source: Authors' illustration

Annex 16. Summary of themes for pathways for smart city initiatives from interviews

PPPs = public-private partnerships; SC = smart city
Source: Authors' illustration

Annex 17. Summary of themes for recommendations based on interview responses



M&E = monitoring and evaluation; R&D = research and development; ICT = information and communications technology
Source: Authors

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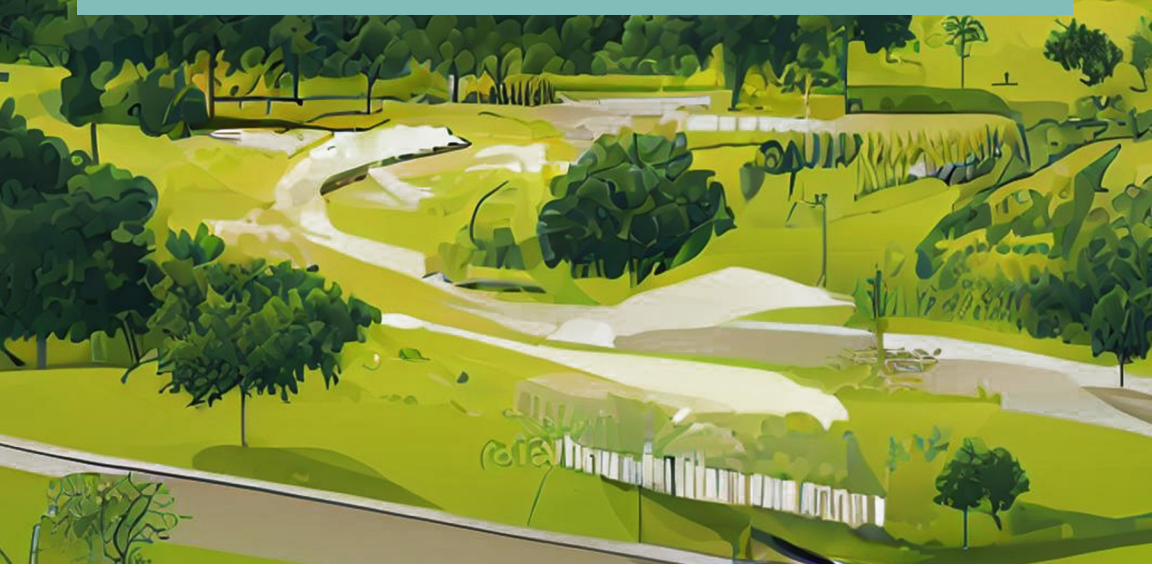
Smart city development is recognized as a potential solution to urbanization issues. This study examines Philippine cities' readiness for smart city development by answering three policy questions: (1) What drives Philippine local government units toward implementing smart city initiatives; (2) What is the extent of smart city development among Philippine cities; and (3) How can the Philippine government facilitate the development of smart cities? A desk review of smart city initiatives in some Philippine cities was carried out, and interviews were conducted with local government units, national government agencies, businesses, and development organizations. It finds that the Philippines has started to tread the path toward building smart cities, and some cities already exhibit readiness. However, additional pathways to smart city development must be paved. There is a need to address funding, data management, and sustainability challenges. Addressing the challenges not only requires actions at the local level but also demands additional support from the national government in developing policies and standards to improve data flow, promoting technology- and innovation-powered cities, and ensuring transparency and accountability in the implementation of smart city initiatives.



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