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Readiness of Philippine Cities to Smart City Development

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Abstract

Smart city development is recognized as a potential solution to urbanization issues, but a disconnect comes along with the vagueness in smart city elements and pathways. The use of the term “smart city” by some local government units in the Philippines evokes a utopia – a local sphere with numerous positive developments that will greatly benefit the constituents. The lack of studies providing evidence on the readiness of Philippine cities to smart city development, however, prevents the establishment of the cities’ capacities to address urban challenges with their initiatives. This study aims to examine whether Philippine cities are prepared for smart city development by answering three policy questions: (1) “What drives Philippine LGUs towards the implementation of 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 and international cities was carried out, and interviews were conducted with stakeholders from selected cities in Luzon, Visayas, and Mindanao. Based on the findings, the Philippines has started to tread the path towards building smart cities, and some Philippine cities already exhibit preparedness for smart city development. Smart city enablers are already in place, but the degree in which they are applied is not very extensive. Both at the national and local levels, there are significant challenges which need to be addressed. These include issues related to data interoperability, national standards on data repositories and application programming interfaces, risk mitigation strategies, monitoring and assessment, accountability, and others. If such issues are unaddressed, there will be a risk of not fully realizing the potential of smart city initiatives being implemented in the Philippines.

Keywords

smart city, digital city, intelligent city, local government, Philippine cities, sustainable city

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1. Introduction

Smart city development is recognized as a potential solution to urbanization issues. The idea warrants a discussion given the persistent and currently even more glaring challenges faced in urban areas. More so for the Philippine urban scene, which despite its potential for development, has faced numerous problems over time.

Majority of the Philippine population in 2015 was found to be residing in the country's urban areas (Philippine Statistics Authority [PSA] 2019). While the size of the population in the country's urban areas is an opportunity for LGUs to leverage human capital, it can also bring in governance issues. Some reviews on the Philippine's urbanization progress reveal limited benefits from urbanization, citing issues 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 became more challenging with climate change and the recent coronavirus disease (COVID-19) pandemic. Persisting urbanization challenges, whose presence have become more apparent with the onslaught of disasters and pandemic, require innovative solutions, one of which can be smart city development.

Some studies have already provided evidence on the impact of smart city initiatives, but they are understandably contextually limited and not that many as the concept is yet to be adopted extensively. A couple of empirical studies used data from cities in China which largely promotes smart cities. Peng (2019) assessed the impact on urban competitiveness (economic competitiveness, sustainable development competitiveness, and livability competitiveness) with 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 (Peng 2019). The key independent variables do not necessarily have significant contributions to all of the urban competitiveness measures, but their positive correlation with the measures reflects conduciveness to the enhancement of overall urban competitiveness (Peng 2019). In other words, a digital life, online government, network society, and information economy create a good environment for urban competitiveness to arise. 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 on health-related variables using Difference-In-Difference and Propensity Score Matching Methods. Wu et al. (2020) showed that building smart cities is: (1) positively associated with enhanced health status; (2) positively associated with enhanced health status through a reduction in the utilization of outpatient services; and (3) positively associated with enhanced health status through an increase in the use of inpatient services. They also relayed that in a smart city construction, rural residents appear to have more significant behavioral

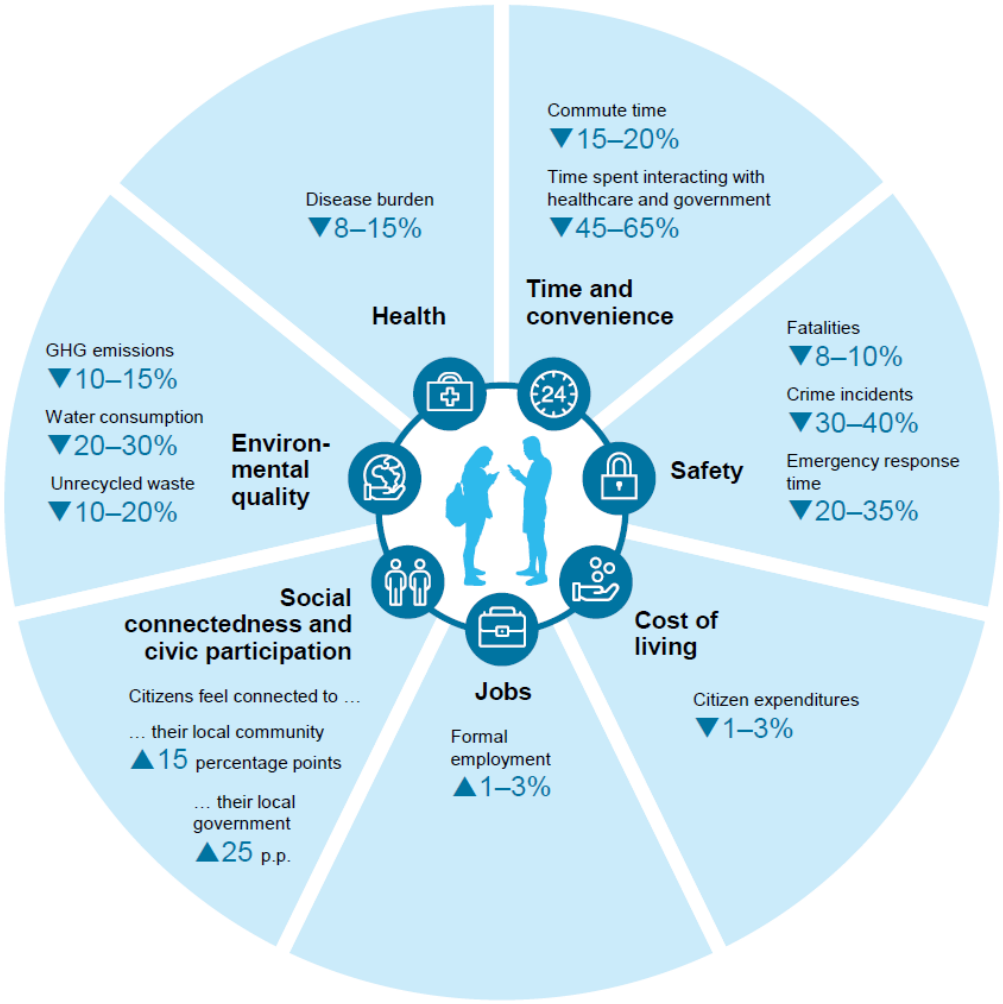
changes in medical service availment compared with urban residents (Wu et al. 2020). Their findings are timely especially now that there is an ongoing pandemic. Overall, the presented pieces of evidence do provide support to the implementation of smart city initiatives although more empirical studies should be conducted in various contexts to fully establish the positive impact of the initiatives.

Given the lack of studies showing evidence on the impact of smart city initiatives, estimations on such impact have been considered. 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 a range of technologies based on research papers, industry reports, publicly available case studies, and McKinsey case studies and data sets (Woetzel et al. 2018). Generally positive estimates are apparent in their quality of life dimensions, which have similar themes with the focus areas in the smart city working definition (Table 2). Woetzel et al. (2018) also provided insights on potential issues such as disruptions on some industries due to higher expectations on products and services, higher need for data protection and security, problems generated by applications, abuse of smart technologies in policing, and large-scale commitments on frequently advancing technology. In addition, Woetzel et al. (2018) relayed the concern on potential high prices of technologies in smart cities, but they found the issue without basis as they estimated as much as 3% of savings on existing annual personal expenditures (electricity bills, hospital visits, etc.) with the use of smart applications. The findings of Woetzel et al. (2018) are definitely insights to consider in determining whether to implement smart city initiatives.

There is a lack of studies providing evidence and estimating the impact of smart city initiatives in the Philippine context, but some local government units (LGUs) have already been attempting to address the urban challenges with smart city solutions. Some LGUs have participated in the ASEAN Smart Cities Network (eg. Manila City, Cebu City, and Davao City) (see Ludher et al. 2018). However, the readiness of Philippine cities to smart city development still needs to be examined. This study aims to contribute to the discussion on such readiness by understanding the concept of smart cities in the context of Philippine cities and answering three policy questions: (1) “What drives Philippine cities towards the implementation of 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?”.

The paper is organized as follows. Section 2 provides insights on and enables readers to explore the smart city concept. Section 3 presents related literature on enablers, barriers, and pathways to smart city development. Section 4 relays the methodology employed in the study to fill in the literature gap. Section 5 discusses NGAs’ initiatives relevant to smart city development. Section 6 gives an overview of smart city initiatives in the country. Section 7 presents a deep dive into the cases of selected Philippine cities. The paper then ends with a conclusion in Section 8 and recommendations in Section 9.

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



Source: Woetzel et al. (2018)

2. Understanding the Concept of Smart City

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.[1] 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, and they relayed that there have already 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 despite a variety of definitions. "Smart city", as used by the LGUs, evokes a utopia – a local sphere with numerous positive developments that will greatly benefit

[1] Stübinger and Schneider (2020) cited "Los Angeles Community Analysis Bureau. The State of the City: The Cluster Analysis of Los Angeles; Community Analysis Bureau: Los Angeles, CA, USA, 1974."

the constituents. As much as constituents would want to live in such an ideal city, a disconnect comes along with the vagueness in 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", *i.e.*, "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".[2]

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 reference to further understand the concept in the context of the Philippines. Constructing a working definition of "smart city" requires a review of the form 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 (Table 1). Made up of 25,200 potential elements, the unified definition was derived using ontology in which greater than thirty-six definitions were deconstructed and assessed (Ramaprasad et al. 2017). It is altered in this research based on a review of international and domestic definitions.

Table 1. Unified definition of "smart city" according to Ramaprasad et al.

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

Source: Ramaprasad et al. (2017)

Reviewed definitions reflect that an innovative and technology-powered system is a suitable structure to handle data, information, and/or knowledge in an aspiring smart city. The Department of Science and Technology – Philippine Council for Industry, Energy and

[2] PNS ISO 37122:2020 categorizes smart city indicators accordingly: (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).

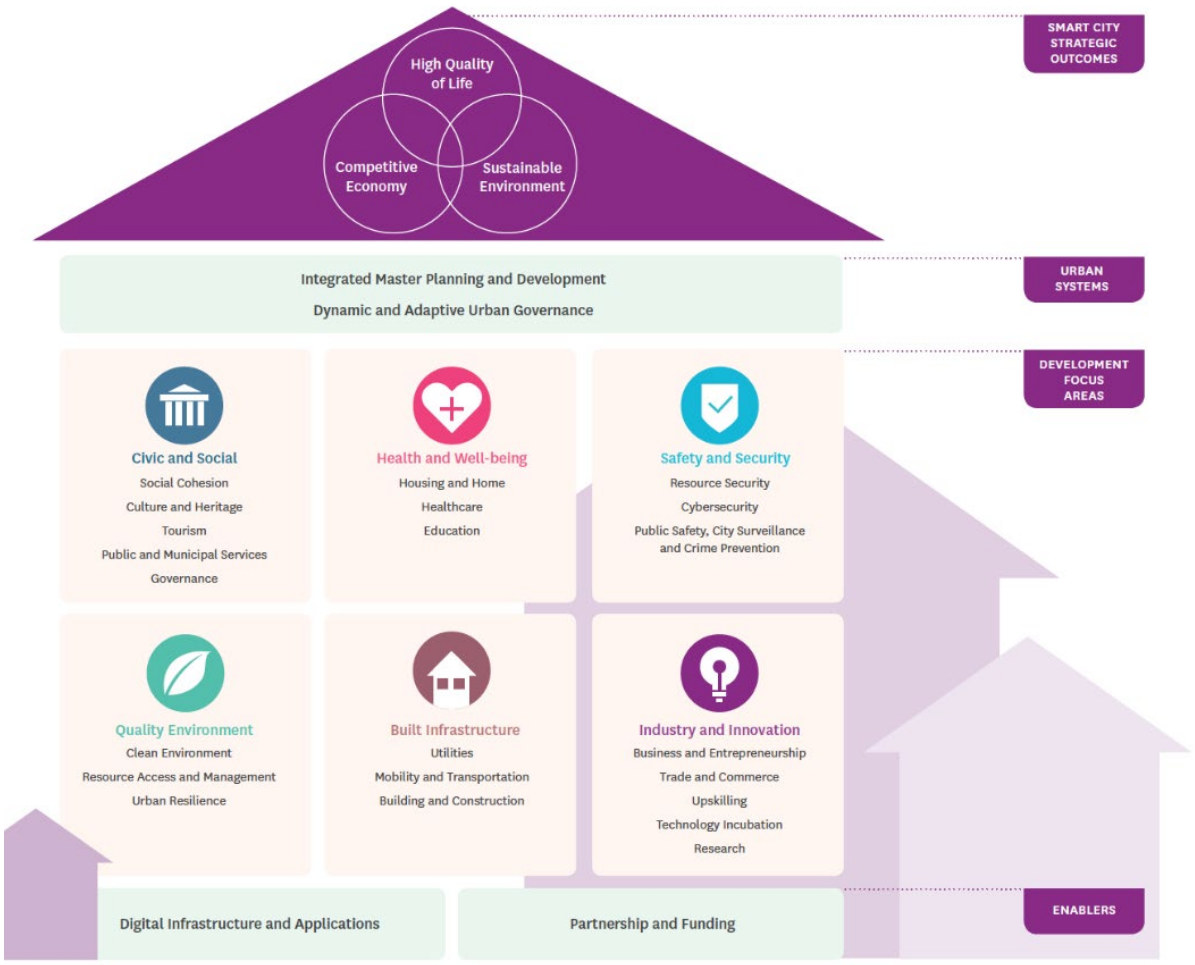
Emerging Technology Research and Development (DOST-PCIEERD) (n.d.-a, p. 4) even defines "smart city" as "an ecosystem comprised of people, organizations and businesses, policies, laws and processes integrated together to create desired outcomes… The city is adaptive, responsive, relevant, and integrates 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; Sánchez-Corcuera 2019; Yoon et al. 2020; Elgazzar and El-Gazzar 2017; Ludher et al. 2018; Albino et al. 2015; McKinsey Global Institute [MGI] 2018; and Department of Information and Communications Technology [DICT] 2019a). Meanwhile, the definition of a smart city in the Association of Southeast Asian Nations (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.13). The importance of technology and innovation to the implementation of smart city initiatives makes these themes inseparable from the system.

Reviewed definitions of smart cities are not specific with 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 Ludher et al 2018; Elgazzar and El-Gazzar 2017; Sánchez-Corcuera 2019; Ramaprasad et al. 2017; Yoon et al. 2020; Albino et al. 2015; MGI 2018; and DICT 2019a). 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 (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 2). Those domains have similarity in the themes found in other literature, such as the identified focus areas of Ramaprasad et al. (2017) and smart city action fields of Yoon et al. (2020). They are also 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 smart city building in the sense that 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). The significance of people in the creation of smart cities is also apparent in many of the other reviewed literature (see Albino et al. 2015; Ludher et al. 2018; Sánchez-Corcuera 2019; Nam and Pardo 2011; and Ramaprasad et al. 2017). Reviewed literature on enablers to be presented in succeeding discussions also reflect the value of stakeholder engagement in smart city development.

Figure 2. ASEAN Smart Cities Framework



Source: Ludher et al. (2018)

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 on smart city definitions. Meanwhile, sustainability as an outcome was mentioned in the papers of Ramaprasad et al. (2017), Elgazzar and El-Gazzar (2017), Toli and Murtagh (2020), and Ludher et al. (2018). Given the support from related literature, the concepts of innovation, sustainability, and efficiency is considered in the formulation of the working definition.

Other potential outcomes include competitiveness, inclusiveness, and economic growth. The three themes are found in related literature. Both 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 of 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 compared with 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.

Smart city initiatives are also believed to enhance quality of life, resilience, and governance based on related literature. Numerous papers have discussed enhanced quality of life as an outcome (Toli and Murtagh 2020; McKinsey Global Institute 2018; Ramaprasad et al. 2017; and Yoon et al. 2020). Furthermore, the DICT (2019a) emphasizes the improvements that smart cities can bring to citizens' welfare and well-being. The emphasis given to 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 from Ramaprasad et al. (2017). Yoon et al. (2020), however, 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, improvement of quality of life, governance, as well as resilience, should be considered in the formulation of the working definition.

Outcomes of smart city initiatives can respectively be grouped under the three categories 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 (Figure 2). The Venn Diagram shown in Figure 2 is open to sub-themes that may arise from the merging of the two or three categories. It gives an idea that outcomes of smart city initiatives are not necessarily exclusive of each other.

2.1 Working Definition

Given the structure, functions, focus, semiotics, stakeholders, and outcomes based on the literature reviewed so far, a working definition is formulated in this research. The unified definition presented in Ramaprasad et al. (2017) was verified through a review on local and international definitions of "smart city". Alterations on the unified definition were made in accordance with the review, leading to the working definition found in Table 2. The working definition defines "smart city" as a technology and innovation-powered system to sense, monitor, process, translate, and communicate 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 (Table 2).

Table 2. 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

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. The World Bank Group (2021) presents the following phases: (1) Infrastructure, (2) Data, and (3) Service. The Infrastructure Phase is made up of geospatial information, and ICT and city infrastructure (World Bank Group 2021). The Data Phase is composed of data sharing and IoT (World Bank Group 2021). The Service Phase is made up of city innovation, and algorithm and service (World Bank Group 2021). Giving consideration to these phases is expected to enrich the assessment.

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

This section relays information on drivers, barriers, and implementation pathways that have been considered essential in the development of smart city initiatives in different countries.

3.1. Discussions on Enablers, Barriers, and Pathways

3.1.1. Enablers

In considering the building of smart cities, LGUs should assess the readiness of their respective cities to carry out related activities in terms of the presence of enablers. Enablers may be necessary or sufficient to successfully implement the initiatives. Given that there are not many pieces of evidence yet, distinguishing between necessary and sufficient enablers is challenging. This subsection shall, nevertheless, attempt to make an initial distinction based on related literature and analysis.[3]

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 to smart cities, where vision is a guide and enthusiasm is fuel for the initial step. Additionally, Jayasena et al. (2019) emphasized vision and goals as key enablers through their

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

review of 52 literature projects, as well as websites, conference proceedings, and other reports. Based on literature and analysis, vision is considered as 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 on smart transformation are regarded as being one step closer to becoming smart cities.

Population as an enabler was also explored, but there is a lack of literature on the matter. McKinsey Global Institute (2018), nevertheless, presented archetypes of cities in Southeast Asia. Agile seedbeds have a population of less than a million people, enabling fast implementation of pilots and scaleups of smart city applications (McKinsey Global Institute 2018). Meanwhile, emerging champions are midsized, with limited financial capacity to suffice required large-scale investment, and with infrastructure that can gain much from more integrative solutions (McKinsey Global Institute 2018). Prime movers are Southeast Asia's biggest primary cities with large inefficiencies, and exhausted social and physical infrastructure systems; and wherein smart city initiatives even at modest levels of adoption are easily feasible (McKinsey Global Institute 2018). Smart city sandboxes are cities with numerous smart applications capturing each urban life domain, and with integrated and strong high-speed communication networks (McKinsey Global Institute 2018). The discussion does not necessarily discriminate in terms of the capacities of cities to successfully implement smart city initiatives given their population size. Population is not considered an enabler, but it would have to be considered in implementing smart city initiatives because of its potential implications.

Economic status appears to have an influence on smart city development. According to Woetzel et al. (2018), income has influenced 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 (Woetzel et al. 2018). Tan and Taeihagh (2020), meanwhile, noted stability in economic progress as an enabler based on their systematic review of 56 studies. Despite the findings of the studies mentioned, being a wealthy city should not be considered as a necessary condition in the implementation of smart city initiatives especially when LGUs have good stakeholder management.

Based on related literature, LGUs can leverage their engagements in their journey to becoming smart cities, including the financing aspect. Jayasena et al. (2019) emphasized the importance of considering stakeholders to be engaged in the 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), government owned 70% of their assessed smart city applications, but they relayed that 60% of the initial investment could come from the private sector. Enhancement of Public-Private Partnerships (PPPs) is also highlighted as an enabler of smart city development by Veselitskaya et al. (2019), who looked at four city cases. Aside from private sector partnerships, LGUs aiming to build smart cities should closely be in touch with their constituents. They should have an in-depth knowledge of their constituents' needs. In connection, 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 a necessary condition to building smart cities.

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

Regulations are enablers to the implementation of smart city initiatives based on related literature. 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 to be derived from smart city initiatives, data security and protection policies need to be in place already prior to the deployment of activities. To emphasize, data protection and security will not only serve the purpose of preventing abuses on data usage, but also encouraging constituents to participate in data provision. The potential benefits from establishing regulations, such as those on data protection and security, turn the policies into necessary enablers of smart city development.

Human capital is obviously another necessary enabler to smart city initiatives. Smart cities, despite being technologically inclined, will not run without the right people. PNS ISO 37122:2020 even has the following relevant smart city indicators: (1) percentage of labor force in the ICT sector, and (2) percentage of labor force in research and development, and education sectors (BPS 2020). Governments should be able to tap people who are technically knowledgeable and competent (Tan and Taeihagh 2020). Woetzel et al. (2018) mentioned, however, that while new roles (eg. data science team, analytics unit, and chief digital officer) have been generated to implement the initiatives, efforts must be diffused over all government aspects. Furthermore, municipal agencies are not exempted from understanding, directing, and monitoring the programs even if they do depend on external providers in the installation and operation of new systems (Woetzel et al. 2018). The city government has to implement its own intelligent solutions while supervising the development of the ecosystem (Woetzel et al. 2018). 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.

3.1.2. Barriers

Many of the identified obstacles to smart city development relate to the lack of the enablers mentioned in the previous subsection. 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. Jayasena et al. (2019), meanwhile, 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. The identification of the already mentioned barriers also emphasizes the roles of the characteristics as enablers to smart city development.

Other barriers have also been identified in related literature. Veselitskaya et al. (2019) noted conflict of interests as an additional barrier. Different groups might have different takes on relevant projects. Depending on the power dynamics, smart city initiatives may push through or not. To reduce uncertainty, stakeholder engagement can be strengthened by LGUs. Jayasena et al. (2019), meanwhile, mentioned political uncertainties as barriers. This implies 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 on technology, environmental concerns, and inclusivity are also barriers. Given the barrier on fragmented authority, the presence of a central authority and strengthened stakeholder engagement is essential (Tan and Taeihagh 2020). The tagging of insufficient investment in basic infrastructure as an obstacle implies that foundation has to be in place to support the adoption of smart city tools. Meanwhile, the inclusion of insufficiency in constituents' knowledge and understanding on technology emphasizes that information dissemination to the public should be considered as a step in implementing smart city initiatives. In terms of the identification of environmental concerns as barriers, Tan and Taeihagh (2020) explained that smart city development leads people to migrate from rural to urban places, which in turn can lead to abrupt ecological stress on the environment. The tagging of the lack of inclusivity as a barrier, meanwhile, implies that smart cities should not only address the needs of selected people but should be helpful to all individuals. The identified additional obstacles should be taken into account to help prevent disruptions in smart city development.

3.1.3. Pathways

The Philippine government may gain insights on the appropriate steps to take in implementing its smart city initiatives by taking notes on the experiences of international implementers. There should be an in-depth review of the pathways taken by other cities that have been successful; however, the lack of empirical studies discussing the impact of smart city initiatives on individual cities is an obstacle. Review of the limited research, nevertheless, has been conducted to unravel potential pathways taken to attain smart city development.

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

Improving data sharing is also a notable pathway. The importance of implementing an open data policy is reflected by the following ISO (2019) smart city indicators: (1) percentage of service contracts wherein city services have policy on open data, and (2) yearly online visits to municipal open data platform for each population size of 100,000. In open data-related initiatives, the public is given power 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. In Noori et al.'s (2020) research on Masdar City, Barcelona Smart City, Amsterdam Smart City, and Smart Dubai, some of the 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, relayed that the success of the latter in terms of 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 are developed to improve public services, and they should be designed for the use of the public. 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, the creation of applications for public usage serves as a necessary pathway in 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 have the objective of constructing smart cities from scratch (Woetzel et al. 2018). They are not built within established cities to avoid getting caught up in previously generated urban planning errors (Woetzel et al. 2018). Meanwhile, there are brownfield projects which 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 are not that many pieces of evidence on the impact of such initiatives. There are pilot projects that have served as lighthouse projects. Some local government units have honed lighthouse projects to reflect their brand and consequently gain investments and pave roads to smart city development (Noori et al. 2020). There have also been data-driven experiments and living labs supported by collaborations among stakeholders (eg. government, constituents, academe, and industry) (Noori et al. 2020). Aspiring smart cities may choose to implement projects suitable to their respective contexts.

3.2. The Cases of Zaragoza, Abu Dhabi, and Busan

International cities of Zaragoza, Abu Dhabi, and Busan have been selected from the Smart City Index to learn from their smart city journeys.[4] The three cities ranked higher than the City of Manila, the only Philippine city in the index, from 2019 to 2021 (Table 3). These cities have also consistently improved their rankings in the index throughout the period, an achievement not attained by Manila (Table 3). 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 towards becoming smart cities. The cases of Zaragoza, Abu Dhabi, and Busan 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. The aim is to provide an idea of the potential way forward of Philippine LGUs in their own smart city development journeys.

Table 3. 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 – 2021)

3.2.1. 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, they started implementing smart city initiatives (Glasco 2018). Former Zaragoza Mayor Juan Alberto Belloch Julbe relayed that the idea promoted was that technological innovation is the key to developing the economy, entrepreneurship, and municipal administration (Zaragoza Ayuntamiento n.d.). He added that Zaragoza's specific achievements include the enhancement of telecommunication networks, and development of electronic administration and open data policy (Zaragoza Ayuntamiento n.d.). Having a vision can clarify the targets of smart city initiatives to be implemented.

[4] 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, in the context of the Smart City Index, a "smart city" is "an urban setting that applies technology to enhance the benefits and diminish the shortcomings of urbanization for its citizens" (IMD and Singapore University of Technology and Design [SUTD] 2021, p. 3). For the index, 120 residents are surveyed on issues relevant to structural and technological pillars with five key areas: (1) governance, (2) opportunities, (3) activities, (4) mobility, and (5) health and safety (IMD and SUTD 2021). Ratings for the Smart City Index are based on perception scores relative to the peers of a city within respective groups created based on UN Development Index scores (IMD and SUTD 2021). Smart City Index 2021, in particular, ranks 118 cities based on weighted perception scores from the last three years of the survey (IMD and SUTD 2021).

Stakeholder engagement is apparently seen as an enabler to 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 a signed agreement with Huawei on the utilization of the company's IoT platform for the development of applications to improve health-related decision-making of constituents (Noori et al. 2020). The project team of Masdar also engaged 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 foundation's engagement with the financial sector, academe, and companies (Zaragoza Ayuntamiento n.d.). Furthermore, it worked with the company ABB for a cloud-based energy management platform (ABB 2019). Zaragoza has also engaged the Regional Government of Aragon to have integrated information systems (Zaragoza Ayuntamiento n.d.). In the case of Busan, third party developers are able to access municipal data, making way for public sector innovation (GSMA 2012). The discussed examples reflect the importance the governments place on partnerships.

Financing of smart city initiatives have been supported by private and public stakeholders. Zaragoza has developed Crowdsourcing ZGZ, a way in which urban planners are able to solicit funds from constituents for citizen-centric urban proposals, while the city matches every Euro (Glasco 2018). The planners' respective 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 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 company from the regional government, is in charge of providing and funding ICT infrastructures through outsourcing or its institutions (Noori et al. 2020). From the discussion, stakeholder engagement apparently also paves the way to have additional financial sources for smart city efforts.

Some cities, such as Abu Dhabi, have branded themselves well as smart city promoters. Noori et al. (2020) noted that Abu Dhabi likes to brand itself (eg. 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 actually converted into a smart city project from an eco-centered project when smart city as a competitive urban policy became a trend (Noori et al. 2020). The City of Abu Dhabi, however, has received criticism on the implementation of its smart city initiatives. Noori et al. (2020) mentioned that the Mubadala Company initially relayed a certain amount of fund 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 as an enabler because of its ability to attract investments.

Data protection is regarded as important in smart city development given some of the cities' relevant initiatives and policies aside from already 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 apparent 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). In the case of the United Arab Emirates (UAE), there is no comprehensive data protection law, but it does have some laws related to privacy law 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 Personal Information Protection Act 2011, which is 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 the formulation of 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 the cases, the issuance of data protection policies at the local level is worthy to be considered as enablers of smart city development.

3.2.2 Pathways

Research and development with various stakeholders are valued by the cities. 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 the Khalifa University (Noori et al. 2020). Masdar also has the Honeywell Masdar Innovation Center aiming to generate innovative smart applications (Noori et al. 2020). Zaragoza, meanwhile, has established the Etopia Center of Arts and Technology, an innovation hub for entrepreneurs, hackers, 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, greenfield and pilot projects have been implemented by the cities. 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 the initiatives of Abu Dhabi include a driverless electric vehicle in Masdar City (Flint 2020). Zaragoza, meanwhile, has worked on the Valdespartera, a community with a centralized control and monitoring system facilitating decision-making through real-time data and remote management of equipment (AVEVA 2020). An example of a pilot project, the Busan Eco Delta City has been 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). Aspiring residents were made to apply (Lee 2020). 18 households would be selected among the applicants, while 36 would be drawn through lottery by the Ministry of Land, Infrastructure and Transport, and Korea Water Resources (Lee 2020). They would undergo a training program for one year prior to their move (Lee 2020). The initiatives include robots that collect waste; smart wearable bands monitoring residents' health and preparing workout plans; and smart homes and unmanned stores (Lee 2020). There would be two model units available for the viewing of visitors (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 to manage and monitor 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 through the setup of digital kiosks at its biggest subway and train station (Park 2021). 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 the monitoring of whether street lighting and public transport are operating well (Spencer 2020). Additionally, Abu Dhabi partnered with Huawei in developing applications for the enhancement of sustainability, productivity, and health to improve the decision-making 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 facilitates 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 for the remote supervision of operations (AVEVA 2020). Various applications and platforms can be developed by aspiring smart cities to realize targeted outcomes.

3.2.3. Extent

The reviewed literature on Zaragoza, Abu Dhabi, and Busan shows a mix of smart city initiatives in the Infrastructure, Data, and Service 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, 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 intended to enhance constituents' decision-making. 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, a number of the 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 third-party developers' open access to municipal data and Busan Metropolitan City's guidelines on personal information process and handling. There is limited information in the reviewed literature, but Zaragoza's apparent initiatives in all three phases could have influenced its higher ranking in the Smart City Index 2021 compared with the two other cities. Among the reviewed literature, there is a lack of information on initiatives of Abu Dhabi in the Data Phase and on initiatives of Busan in the Infrastructure Phase. Additionally, Zaragoza, has been able to relay its outputs comprehensively. In its strategic plan on smart city development for as early as the years of 2012 to 2015, Zaragoza was able to specify its accomplished smart city initiatives (Zaragoza Ayuntamiento n.d.). Zaragoza's extensive initiatives, backed up by documentation, makes it one of the international cities to look out for.

4. Methodology

A desk review of smart city efforts in some Philippine cities was conducted. This was complemented by interviews with LGUs and other stakeholders from selected cities in Luzon, Visayas, and Mindanao. The interviewed stakeholders include LGU officials and their respective partners in smart city initiatives, as well as national government agencies (NGAs). Responses are assessed relative to those of other stakeholders, and contents of shared documents and online references.

Table 4 presents the Philippine LGUs interviewed for this study. Prior to the interviews, a desk review was conducted to initially identify LGUs with high and low level of implementation. LGUs with high level of implementation are regarded as those already implementing numerous smart city initiatives. Given a potential influence of income and population on smart city development, LGUs with low level of implementation were selected with consideration on the income class and population size of the LGU with high level of implementation in the same island group. Although with limited evidence, greater weight was given to the income class over population based on the assumption that income class has greater influence on the pace of smart city development compared to population size because of the availability of resources. A total of seven LGUs were interviewed for this study.

LGU officials interviewed for each selected site vary depending on availability and point persons identified through the snowball sampling method. The snowball sampling method was adopted given that LGUs are expected to have different offices and different approaches to implementing policies. The set of interviewees per selected site may include the mayor's office, *sangguniang panlungsod*/ city council, and other officials with potential involvement in carrying out smart city initiatives (eg. City Planning and Development Office, and Information Technology Department). Topics discussed with interviewed LGUs include their definition of "smart city"; smart city development phase in which LGU implements smart city initiatives; enablers of smart city development; addressing financial requirements for smart city development; expected influence of Mandanas Ruling on financing aspect; challenges and potential solutions; and implementation pathways to support smart city development. In addition to analyzing the interviews with LGUs, contents of relevant LGU documents and online references were reviewed.

Table 4. Interviewed LGUs in the Philippines

Island Group	Local Government Unit	Income Class	Population	Level of Implementation Based on Initial Review
Luzon	Cauayan City	3rd	143,403	High
	Tuguegarao City	3rd	166,334	Low
	San Fernando City	1st	354,666	High
	Malabon City	1st	380,522	Low
Visayas	Mandaue City	1st	364,116	High
Mindanao	Davao City	1st	1,776,949	High
	Tagum City	1st	296,202	Low

Source of income class and population figures: PSA (2021a-g).
Note: According to PSA (2021a-g), the population is based on the 2020 Census.

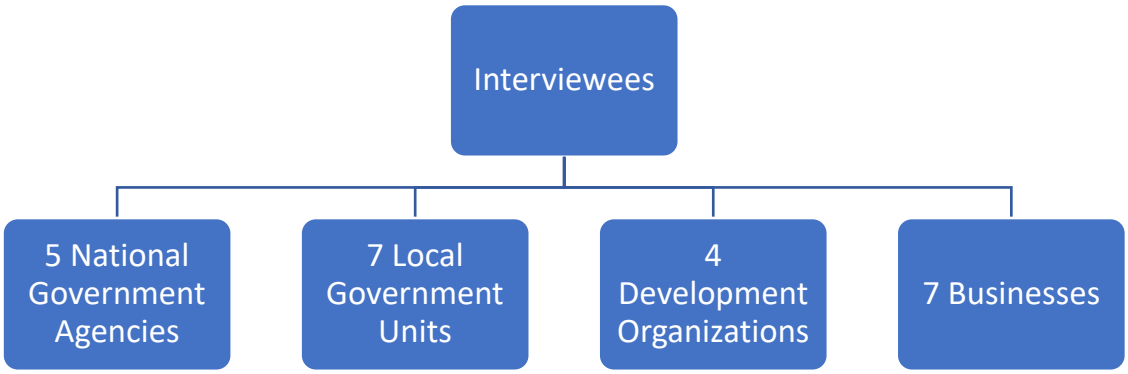
Private sector stakeholders involved in some of the LGUs' smart city initiatives were also interviewed to enrich the analysis (Figure 3). The snowball sampling method was adopted in the inclusion of the partners in the research, the first point of contact being the interviewees from the LGUs. During the meetings with LGU interviewees, their initiatives were discussed. Some private sector entities engaged in some of the discussed initiatives were invited for interviews to gain more insights on their involvement. Topics discussed with interviewed private sector stakeholders include their definition of a "smart city"; LGU smart city initiatives they support; reason for engaging with LGU on smart city initiatives; support in relation to LGU's smart city initiatives; challenges encountered in engagement with LGU; implementation pathways government can take to gain more private sector participation in smart city initiatives; and lessons learned from developing and implementing smart city initiatives with LGU.

The interviewed private sector entities include four development organizations and seven businesses. Interviewed development organizations are supporting the Infrastructure and Data Phases of smart city development. They are involved in networking, financing, 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, while those involved in the Data Phase provide data-relevant technology involving Safety and Security, and Built Infrastructure. Meanwhile, interviewed businesses are supporting the Infrastructure and Service Phases. Activities of interviewed businesses include providing service, technical support, networking, financing, consultancy, and manufacturing. Those involved in the Infrastructure Phase donate and provide infrastructure technology involving focus areas of Built Infrastructure, Quality Environment, and Industry and Innovation, while those involved in the Service Phase provide technology involving focus areas of Safety and Security. The discussion gives a preview of the importance of the private sector entities in smart city initiatives.

Meanwhile, some NGAs with potential involvement in smart city development were also interviewed (Figure 3). Topics discussed with interviewed NGAs include their definition of "smart city"; smart city development phase 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 Interior and Local Government (DILG), DICT, DOST-PCIEERD, Public-Private Partnership (PPP) Center, and National Privacy Commission (NPC). The NGAs are included in the research because their mandates reflect their potential influence on building smart cities. For instance, the DILG (2013) is tasked to provide support in terms of supervision over local governments. Meanwhile, the DICT (n.d.-a) is in charge of the planning, promotion, and development of the national ICT agenda according to Republic Act No. 10844. The DOST-PCIEERD (n.d.-b) functions as 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) is in charge of facilitating the implementation of PPP projects and program. Meanwhile, the NPC is mandated to carry out the Data Privacy Act of 2012 (NPC n.d.). The discussion provides insights on 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 to smart city development. They are utilized to address the policy questions on drivers and extent of smart city development in the cities whose LGUs were interviewed, and pathways the Philippine government can take to facilitate the development.

Figure 3. Interviewees



Source: Authors' summary

5. 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 in the Infrastructure, Data, and Service Phases of smart city development, as well as in the preparation of LGUs in implementing relevant initiatives.

A framework has been developed by the DOST-PCIEERD for smart sustainable communities and cities, and it has been encapsulated in a document (Figure 4). DOST-PCIEERD 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-PCIEERD n.d.-a). 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 (DOST-PCIEERD n.d.-a). 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 (DOST-PCIEERD n.d.-a). DOST-PCIEERD (n.d.-a) promotes the conduct of a Gap Assessment and Priority Setting. The agency also enumerated smart city indicators for sustainable development of communities with the following themes: (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. The framework prepared by the DOST-PCIEERD can help guide smart city initiatives.

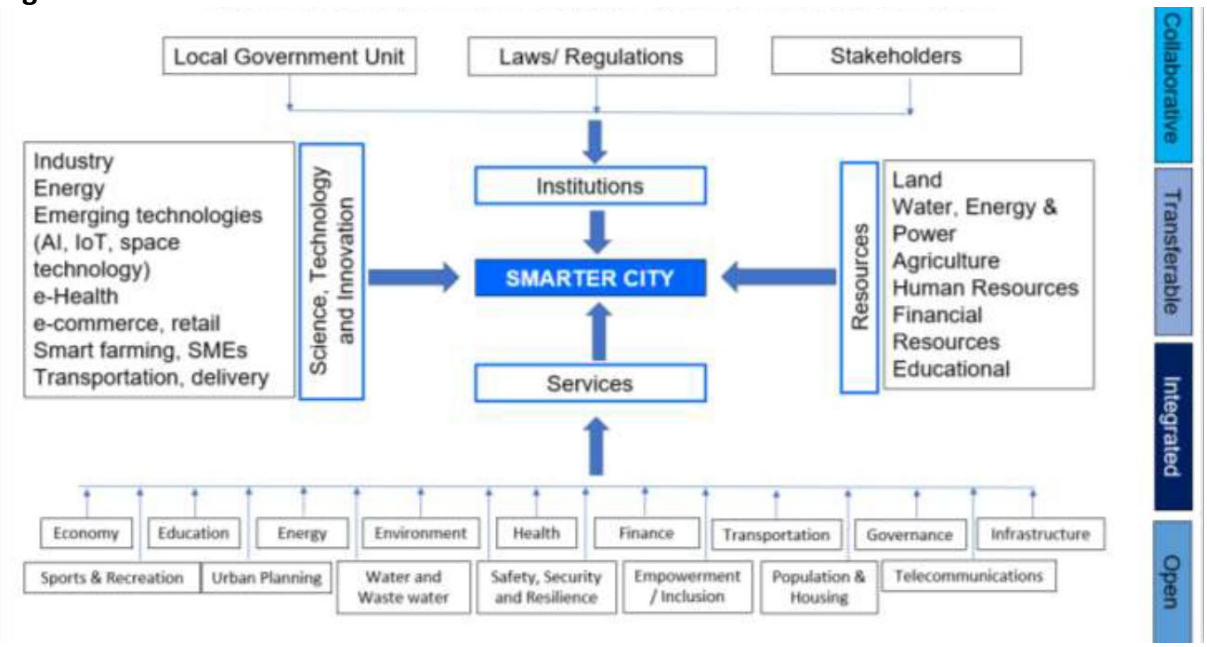
The PPP Center can also support smart city development. It has potential to guide LGUs with smart city PPP projects given its expertise in PPPs, which is already a mode of partnership used in international cities. The PPP Center is also ideal to tap because of its recording and data sharing practices. 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). Its basis for prioritization of projects is enclosed in the Public-Private Partnership Governing Board Guidelines on the Identification, Selection, and Prioritization of PPP Project (see PPP Center n.d.-c). Some of the elements the PPP Center have looked at in evaluating projects through a Multi-Criteria Analysis are institutional readiness of the implementing agency, appropriate risk sharing, manageable life cycle costs, and market acceptability (see PPP Center n.d.-c). Furthermore, some projects are placed under the Project Development and Monitoring Facility, a revolving fund for pre-investment activities, such as feasibility studies (Camus 2021). The PPP Center can provide aspiring smart cities with support in the development of their projects.

5.1. Infrastructure Phase

Within the Infrastructure Phase, the DOST has the potential to provide support. The DOST-PCIEERD has been issuing some calls for proposals, such as those under the Convergence of Emerging Technologies / Sectors Towards Industry 4.0 and Smarter Cities and Communities

in the Philippines (DOST-PCIEERD n.d.-c). It covers projects including sensors and actuators for intelligent factories, development of 5G products and applications, space technology applications in public services, and sustainability through innovation in cities (DOST-PCIEERD n.d.-c). The DOST also has the CRADLE Program wherein Philippine businesses collaborate with Research & Development Institutions and/or the academe for product and operations development (DOST 2021). Under the program, businesses are required to commit to adopting the technology and shell in at least 20% of counterpart financing (DOST 2021). The DOST-PCIEERD initiatives are expected to help strengthen the foundations of smart city development.

Figure 4. DOST Framework for Smart Sustainable Communities and Cities



Source: DOST-PCIEERD (n.d.-a)

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 megabits per second 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 to the deployment and use of smart city tools, the DICT's NBP is expected to support smart city development.

Other potentially supportive programs within the Infrastructure Phase is the DICT's Free WiFi for All Project. The DICT has been implementing the Free WiFi for All Project to increase access of Filipinos to the Internet (DICT n.d.-b). The implementation of the project is supported by Republic Act (RA) No. 10929 or the "Free Internet Access in Public Places Act". Under the law, free access to Internet service in public areas (eg. public transport terminals and public hospitals) shall be given across the country with DICT as the lead implementing agency (RA No. 10929). The agency is also mandated to ensure the availability of Internet at the minimum speed per user (RA No. 10929). The DICT's Free WiFi for All Project can address lack of connectivity among constituents.

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 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 IT-BPM jobs (Dela Cruz 2020). Interventions under the program include stakeholders and design thinking workshops, as well as strategic planning, to support countryside cities in developing 5-year ICT industry roadmaps (DICT 2021a). According to Undersecretary Emmanuel Rey Caintic, interventions would also include connectivity enhancement support from the DICT (Dela Cruz 2020). The Digital Cities Program with its comprehensive approach to countryside development can help in building smart cities.

5.2. Data Phase

Within the Data Phase, there can be a secure flow of data through the implementation of RA No. 10173 or the Data Privacy Act of 2012. RA No. 10173 sets out the policy of the State to ensure free-flowing information for development while safeguarding privacy. It also has provisions on data subjects' rights, as well as penalties to unauthorized personal information processing. RA No. 10173 established the National Privacy Commission, whose mandates include engaging with government agencies and the private sector in the designing of policies and plans to improve security of personal information, as well as the monitoring of compliance to standards on data protection (RA No. 10173). The NPC also has statistics on breach notifications. NPC, through RA No. 10173, has the capacity to ensure data protection.

Emphasis on data sharing comes along with the policy to protect data. The government has been implementing the Freedom of Information (FOI) Program in accordance with Executive Order (EO) No. 2, Series of 2016. LGUs are encouraged to refer to the Order (EO No. 2, Series of 2016). EO No. 2, Series of 2016 provides that each Filipino should have access to public and official records; information; government research data; and papers and documents pertaining to official acts, decisions, or transactions. The Presidential Communications Operations Office serves as the coordinator for the FOI Program (Republic of the 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

(Republic of the Philippines n.d.). The FOI Program offers an open data mechanism that is consistent with the smart city concept.

Various platforms can be tapped to gain access to data. The platform Open Data Philippines, managed by the DICT, has been made available to increase access to datasets from government agencies (DICT n.d.-c). 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). Another platform OpenStat, managed by the PSA, increases access to PSA-gathered data (PSA 2021h). The datasets are divided into the following domains: (1) environment and multi-domain statistics, (2) economic statistics, and (3) demographic and social statistics (PSA 2021i). 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. In collaboration with the Development Academy of the Philippines and the Presidential Communications Operations Office, the DOST-PCIEERD has been implementing the Smarter Philippines through Data Analytics Research and Development, Training and Adoption (SPARTA), targeting 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, funding data science research and development projects that would enhance operations of LGUs and NGAs (DOST-PCIEERD 2021). The capacity building programs of the DOST-PCIEERD can ensure the availability of human capital that will support smart city building.

5.3. Service Phase

RA No. 11032 or the "Ease of Doing Business and Efficient Government Service Delivery Act of 2018", supports the Service Phase of smart city development. Under RA No. 11032, NGAs and LGUs have been mandated to re-engineer their respective procedures and systems in accordance with the law, which includes a provision on zero-contact policy. The DICT was mandated to, in consultation with the NPC, develop a Central Business Portal that would serve as a central system for the applications for business-related clearances, permits, licenses, or authorizations issued by LGUs (RA No. 11032). In the Joint Memorandum Circular No. 1, Series of 2016 of DILG, DTI, and DICT, the LGUs are encouraged to computerize and automate their business permit process, and use electronic and online mechanisms for efficient business processing. The policies can help encourage LGUs to implement smart city initiatives because of the potential of such efforts to ensure ease of doing business and efficient government service delivery.

6. Overview of Smart City Initiatives in the Philippines

Determining the alignment of the working definition and relevant themes found in other countries with the Philippine context requires an inspection of the experiences of local cities in implementing smart city initiatives. Apparently, many cities in the countries' metropolitan areas have been using smart city tools, and some are in the process of planning and/or establishing agreements with stakeholders. This section teases out existing efforts based on online references.

6.1. Metro Manila

The Internet is obviously being valued by aspiring smart cities in Metro Manila. According to Mayor Mar-Len Abigail Binay, 25 *barangays* in Makati City are equipped with a fiber optic cable loop, enabling access to a free WiFi service in particular periods per 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 the improvement of cellular bandwidths through mobile signal boosters (A.J. Marasigan 2019). Free WiFi 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). Furthermore, San Juan City forged a partnership with Globe to create WiFi zones in some public areas and *barangays* (Marquez 2019). Also in San Juan City, free WiFi was set up in particular sites through a cooperation with the DICT (Umali 2019). Additionally, Smart Communications Inc. engaged with Las Piñas City, Mandaluyong City, Malabon City, Parañaque City, and San Juan City to provide free WiFi to residents 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 in the deployment of KonekTayo Wifi buses serving as hotspots to particular areas at designated periods per 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 phase of building a smart city.

In some cities, some identity documents (IDs) and platforms are being used in government transactions. Manila City has provided IDs to some constituents, enabling cashless distributions and payments (PayMaya n.d.). Allowances and benefits can be stored via the IDs, which can then be used in buying from merchants and mobile *Kadiwa* shops, transferring money, purchasing load, and paying bills (PayMaya n.d.). Meanwhile, Manila City's Go Manila Online Services enable the processing of licenses, permits, health certificates, birth certificates, and community tax certificates (City of Manila 2020). 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 in providing Makatizen Cards to some constituents for free (Manila Bulletin 2020). The Makatizen Card is used in the distribution of 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 (A.J. Marasigan 2019). Pasay City also introduced the *Electronic Mamamayan ID*, a city ID which can at the same time be used in contact tracing,

commerce, and as an e-wallet for the distribution of financial aid (Nazario 2021). Through IDs and platforms, government transactions are made easier by some LGUs in Metro Manila.

Online and mobile payment platforms for constituents have also been deployed and/or used in some cities in Metro Manila. Caloocan City, through the Link.BizPortal of the Land Bank of the Philippines (LANDBANK), enabled the payment of Quarterly Business Tax and Real Property Tax via mobile devices or computers (LANDBANK 2020). Navotas City has a similar engagement with LANDBANK through the Link.BizPortal, and it can monitor relevant collections each day in real-time (LANDBANK 2021). Makati City, in collaboration with the digital arm of Smart and PLDT called NeoConverge, 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 City and Parañaque City 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 for Parañaque to enable cashless, contactless, and paperless transactions with the LGU (see City of Manila 2020 and Business World 2021). Quezon City also enabled the government-related payments through a mobile and online platform (Koh 2017). The City of San Juan has a mobile and web application, enabling constituents to pay real property tax through online and mobile methods (City of San Juan Local Government System 2020). Additionally, Marikina City has engaged with Bayad Center for the payment of bills via modes including through a smart city application (INQUIRER.net BrandRoom 2020). Valenzuela City has an online application system that processes business permit applications from filing to payment (Tuquero 2019). The mentioned platforms are expected to facilitate payment transactions.

Health and well-being are the focus of some smart city platforms currently being implemented. Manila City has planned to create tutorial applications in which teachers can guide their students in their respective 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 training for teachers, online resource hub for seniors, 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 of the 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 (eg. notification to constituents on COVID-19 test results, and deployment 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 they are almost getting their respective turns (Cepeda 2020). The smart city platforms can help increase the quality of life of constituents.

Businesses can obviously gain from smart city initiatives, including the adoption of mobile platforms. As reflected in previous examples, private sector companies have collaborated with LGUs in the implementation of smart city initiatives, providing them a potential source of additional income. They also benefit from the online platforms that facilitate the settlement of

government transactions and payments. Aside from such gains, businesses have become direct beneficiaries of smart city projects. For instance, the City of Navotas also teamed up with Grab Philippines for the onboarding of businesses, as well as drivers, on Grab-related applications (Speed Magazine 2020). Furthermore, Valenzuela City collaborated with Grab Philippines in creating a mapping system with local data to increase efficiency and accuracy of deliveries through the application (Malaya Business Insight 2019). Given the potential advantages of smart city initiatives to businesses, companies can include collaborating with aspiring smart cities in their agenda.

Some LGUs in Metro Manila have been attempting to increase the ability of their respective constituents to communicate with them. The Makatizen App enables constituents to be informed, and relay issues including 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 complaints of constituents 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 in the analysis of the respondents' approval or disapproval of LGU-formulated statements on open streets (Ranada 2020). LGUs' efforts in increasing communication with their constituents reflect their understanding on smart cities' people-centric concept.

Safety and security are themes being focused on by some smart city initiatives in Metro Manila. For instance, Pasay City, with its Electronic Mamayan ID project, established a cloud server-enabled citizen registration management system containing information and data of registered citizens that can be utilized by other government agencies during emergency crisis situations for more efficient response (Nazario 2021). Additionally, smart city technologies were piloted in Caloocan City in collaboration with Iveda (Smart Cities World Forums 2019). Iveda technologies, including facial recognition and license plate recognition, are able to trigger actions without physical human intervention (Smart Cities World Forums 2019). Meanwhile, Makati City has Command Center Vans with telecommunication equipment connected to the mainframe of the LGU, enabling governance continuity even when there are disruptions presented by disasters (A.J. Marasigan 2019). The city also plans to enable the delivering of live images from the body cameras of law enforcers to the LGU's command centers (A.J. Marasigan 2019). Additionally, Makati City installed closed-circuit television cameras (CCTVs) in line with disaster risk reduction and management (Cepeda 2020). In Pasig City, there is the computer-aided dispatch project (where incident reports are sent real-time to emergency services), emergency network Global System for Mobile Communication (GSM) System project (where emergency cellular calls are routed and text messages are sent during calamities), and flood awareness simulation tool (where scenarios and information of flood-prone areas are presented) (The Good News Pilipinas Team 2018). Meanwhile, Quezon City has an Emergency Operations Center, a monitoring system for issues including those related to emergencies and security (Koh 2017). In the City of Taguig, the Taguig Weather Monitoring System was set up to give information and updates on phenomena such as disasters, storms, and weather conditions at real-time using cameras and analytics (Caliwan 2020). Furthermore, Mandaluyong City, along with PLDT, deployed Smart SOS Dispatch solution and CCTVs (Valencia 2018). Marikina City, meanwhile, has planned to be equipped with a camera surveillance system, command center with access to a computer-aided dispatch system, digital radio handset, Internet Protocol (IP) cameras, teleconference endpoint, one-key emergency

button devices, and digital information display from China International Telecommunication Construction Corporation according to the Department of the Interior and Local Government (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 has planned to have CCTVs in some areas in the city (Villanueva 2008). The relayed cases show how important safety and security are in Metro Manila.

Other highlighted focus of smart city initiatives in Metro Manila includes quality environment and mobility. This is exhibited in Manila City's engagement with the Rotary International, United States Agency for International Development, community groups, and government agencies for the Sta. Ana Public Market Wastewater Treatment Plant, facilitating maintenance and operation, and reducing costs of wastewater treatment (Gambrill n.d.). Pasig City, meanwhile, 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's) "Green Delivery" electric vehicles which conduct deliveries (Quadra-Balibay 2020). Pasig City has also collaborated with the Ateneo de Manila University 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 hpa, is envisioned to have driverless railway system, water taxis, and smart grid enabled by artificial intelligence to monitor energy production, consumption, and transportation; and to use solar and tidal energy (Seow 2017). Valenzuela City, meanwhile, established a solar power farm (Olandres 2015). In addition, Makati City has eyed a shift to electric-powered/hybrid vehicles (A.J. Marasigan 2019). Apparently, the attainment of a quality environment is on the agenda of some Metro Manila LGUs.

6.2. Metro Clark

Internet connection is being valued by some aspiring smart cities in Metro Clark. According to Information Communications and Technology Division (ICTD) Assistant Network Administrator Gilbert David of Angeles City, internet connection and network equipment in the city hall were enhanced to increase efficiency of online payment, while networks of installed data cabinets were consolidated to build a centralized server (Carbungco 2020). Meanwhile, Mabalacat City engaged with the DICT and Metro Clark Information and Communications Technology (MCICT) to install free WiFI in key areas, such as the city hall, through a project called "*Pipol Konek*" (Navales 2018). Additionally, San Fernando City engaged with Smart Communications, Inc. to provide free fiber-powered WiFi through Google Station (Smart Communications 2019a). Metro Clark cities apparently place importance on the Internet as exhibited in the presented cases.

Platforms with civic and social focus are being promoted in some of the cities. Angeles City has implemented online services covering the collection of real property taxes; and the issuance of occupational and business permits; health, community tax, and birth certificates; and licenses (City of Angeles 2020). The city has also been setting up a system where constituents have the option for cashless payment in public transportation and markets (Gunio 2020). It has

also planned to deploy kiosks in each *barangay* to enable constituents to pay basic traffic violations, and real property and business taxes (Gunio 2020). The platforms cater to constituents wanting additional payment options in their government transactions. San Fernando City has also been continuously boosting their online Business Permit Application System since 2017 (Flora 2021). They have also 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 also key themes in some smart city initiatives. In San Fernando City, a command and control center was planned to be equipped with light emitting diode (LED) boards for the safety of motorists, cable for voice facilities for collaborating with other government offices, computer-aided dispatch system, and video management system (Tecson 2018). Angeles City has also been eyeing the expansion of the Angeles City Emergency Disaster Command Center (Gunio 2020). Some other smart city initiatives focus on health such as Angeles City's implementation of the StaySafe.PH mobile application for COVID-19 contact tracing (Dharmaraj 2020a). Safety, security, and health add to the list of areas in which some Metro Clark LGUs have initiatives.

6.3. Metro Cebu

Cebu City has won awards for its efforts in integrating ICT in their delivery of public services. One of these is the Cebu Business Application and Online Analytics (CEBALA) project (Dagooc 2018). This was recognized in the 2018 Digital Cities Philippines Awards Night as a world class ICT system at par with international or internationally-recognized standards (Dagooc 2018). Another is their GeoHazard Mapping Information System to be utilized for better disaster preparedness and management (Dagooc 2018). These awards show how committed Cebu City is to making the delivery of services more efficient through technology.

Safety and security, and quality environment are themes being forwarded by some smart city initiatives in Metro Cebu. Mandaue City installed a CCTV system and implemented the Guardian Emergency Response System, which is an application enabling a one-touch key to relay incidents and get assistance in times of emergency (SunStar Cebu 2019). Cebu City has also planned to install higher resolution CCTV cameras (ASEAN 2018). Meanwhile, Naga City is promoting the use of circular economy technology (see Neola 2021). The discussion reflects the value the respective cities have placed on the focus areas.

Meanwhile, visualization is highlighted in some smart city plans. Cebu City has plans of leveraging a centralized Geographic Information System (GIS) with data and developing 3D context models in the implementation of projects (Bhattacharya 2018). Such plans would hopefully pave the way for the creation of a digital twin.

6.4. Metro Davao

Some cities in Metro Davao have been laying the foundation to the implementation of smart city initiatives. Davao City has been installing WiFi in some key areas such as the local airport (The Economist 2017). Meanwhile, a TECH4ED station was established in the Center of Justice Building in Tagum City for technology empowerment in the areas of entrepreneurship, employment, economic development, and education (Tagum City Information Office 2018). The project, a collaboration between DICT and Tagum City's Public Education and Employment Services Office, was launched in 2018 (BusinessWorld 2018). Internet access is apparently being prioritized in some of the cities in Metro Davao.

Some Metro Davao cities value safety and security as reflected by their initiatives. Davao City has a centralized dashboard linked to CCTV cameras (The Economist 2017). It also aims to install additional CCTVs to capture key facilities and each intersection (ASEAN 2018). The city also engaged with IBM in developing a centralized operations dashboard where information from various city agencies is incorporated and processed in real time, enhancing responses in times of disasters and emergencies (Madrazo-Sta. Romana 2012). According to the DILG, Davao City's Converged Command and Control Center has reached two out of the five phases of its implementation, wherein additional CCTVs, aerial installation of fiber optic cables, underground cables, and digital infrastructure are being deployed (Chavez 2021). The initiatives are expected to help increase the quality of life of constituents.

Mobility is also being focused by some aspiring smart cities such as Davao City. The City of Davao aims to create a High Priority Bus System to be complemented by an improved traffic signalization and traffic management center (Burgos 2019). Given that some areas in Davao City are prone to heavy traffic, mobility-related smart city initiatives are appropriate.

Some cities in Metro Davao also aim to face the ongoing pandemic with smart city initiatives. The City of Davao aims to notify constituents on contract tracing protocols and personalized status with the help of QR codes (eg. suspected COVID-19 carrier) (Miranda 2021). Such applications are useful especially in emergency situations.

Another project in Metro Davao is Hijo Central in Tagum City. According to Ms. Rosanna Tuason-Fores of Hijo Resources Corporation, the developer of the project, Hijo Central is envisioned to be a smart city – a hub of biotech, agritech, and foodtech (Alama 2019). She added that a platform will be in place to directly link farmers to the market (Alama 2019). A food innovation hub is also targeted to be created in Hijo Central (Perez 2019). A project like Hijo Central can serve as a pilot area for the implementation of smart city initiatives.

6.5. Other HUCs

The rest of the highly-urbanized cities or HUCs are also working on improving connectivity in their areas. Last 2020, Baguio City signed a MOA with the DICT for the establishing of a

broadband network and accelerated implementation of their latter's Free Wi-Fi in public spaces program (DICT 2020b). Lucena City with DICT also launched more Free Wi-Fi sites as the city transitions to the new normal (DICT 2020c). Meanwhile, PLDT expanded the coverage of their fiber and wireless networks and fiber-to-the-home (FTTH) infrastructure in Puerto Princesa (SMART Public Affairs 2021a). The Smart Barangay Connect also expanded their program in General Santos City, Cagayan de Oro City, and Iligan City (Smart Communications 2021). Also in partnership with 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 this 2021 to discuss the plans of providing fast fiber internet service for its citizens (Guadalquiver 2021). The efforts in increasing connectivity in their areas show the importance of laying down necessary tools or infrastructure that would enable smart city technologies to flourish.

The HUCs are also focusing on civic and social initiatives. Iloilo City has a *City Serve* city portal and the Iloilo City Mobile App to make government services more accessible and ease transactions (Lena 2018). Meanwhile, Baguio City's Electronic Budget Operations and Monitoring System or eBOMs and Cagayan de Oro City's electronic budget system have won awards in the Digital Governance Awards for being world class ICT systems (DICT 2019b). In response to the pandemic, other HUCs such as Iloilo, Tacloban, and Zamboanga City also implemented contact tracing apps and online vaccine registration platforms (Burgos 2020, APEC 2021, and City of Zamboanga 2021). Apart from addressing civic and social issues, these efforts also address issues on health and well-being. The different Covid-response apps can also be used to improve the healthcare systems of the cities. On the other hand, ICT platforms such as the Technology Empowerment for Education, Employment, Entrepreneurship, and Economic Development or TECH4ED, are also being implemented in different cities and municipalities. Aside from being a conduit for government services, the TECH4ED centers are also portals for information, communication, technology, non-formal education, skills training, telehealth, job markets and business services (see DICT n.d.-e. and PSA n.d.). Other notable digital hubs project of HUCs that enhance digital skills of its citizens are Butuan City's *DigiBayanihan* project and DICT's digital hub in Zamboanga City's (EIFL n.d.; DICT 2020d). These initiatives not only enable more efficient delivery of services but also empower citizens to becoming more digitally literate.

Safety and security are also being focused on by the rest of the HUCs. This 2021, Baguio City inaugurated their Smart City Command Center (Agoot 2021). Partnering with Cisco Systems, Inc., the command center will be using the Smart City System, which is the first single smart city platform in the country (Daroya 2021). Components of this include an Integrated Communication Platform (ICP), a Video Management System (VMS) with Video Analytics, Computer Aided Dispatch (CAD), and GIS (Amadora 2020). The project will be implemented in three phases. Aside from this, Baguio already invested in other technologies for digital governance, crowd density monitoring, and real-time weather prediction (Dharmaraj 2020b). Meanwhile, Puerto Princesa City invested on a smart lighting system, which is a data powered 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 in power interruptions in the city. Cagayan de Oro City and General Santos City are also working on completing the traffic light and signalization system with CCTV projects in their respective cities (see CDODev 2018 and MindaNews 2021). Additionally, as part of the Baguio's smart city system,

they are also looking into investing in a Smart Mobility System that will use artificial intelligence for traffic management and contactless apprehension (See 2021).

Some of the initiatives related to security also covers issues on quality environment. For instance, PHIVOLCS signed a MOA with eight cities[5] for the implementation of the *GeoRiskPH* (USAID 2021). This initiative aims to utilize platforms that will collect and process hazard data and risk information for a more efficient disaster risk management (USAID 2021). Meanwhile, smart groundwater monitoring systems to improve resource management were piloted by the DOST and the Ateneo de Manila University in certain water-critical cities in the country (DOST-PCIEERD 2020b). Most of the cities included in the pilot areas are HUCs such as certain cities Metro Manila, Iloilo City, Zamboanga City, and Cagayan de Oro City. Given that the Philippines is a tropical country and is located in the ring-of-fire, initiatives to manage climate-related impacts are important.

HUCs are also increasingly incorporating digital aspects on their development plans. This year, the cities of General Santos, Iligan, Puerto Princesa, and Zamboanga launched their five-year digital city roadmaps (Balinbin 2021). These roadmaps aim to improve their readiness for the digital economy as part of the Digital Cities Program of bridging the progress gap in non-metro localities. In addition, General Santos City was recognized by the Digital Governance Awards for its use of GIS in the assessment of 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 that will utilizes science, technology and innovations (STI) to improve governance (Santiagudo 2019). Meanwhile, the *TriCity ICT Caravan* program in Bacolod is being implemented to spur the growth of the IT-BPM sector in their area (Nicavera 2020). These efforts show the growing commitment of HUCs to developing their cities into smarter ones.

6.6. Other Non-HUCs

Compared with the HUC counterparts in Metro Clark[6], Cebu[7], and Davao[8] and other 1st income class cities like San Fernando City and Tagum City, not many reports on the initiatives of the non-HUCs in the metropolitan areas can be found online. Most of them only mentioned the enhancement of internet connectivity in their areas and use of online platforms for different services, but not much on the implementation of city-specific initiatives. A roadmap study for the sustainable urban development in Metro Cebu has been done by the Metro Cebu Development and Coordination Board (MCDCB) in partnership with the Japan International Cooperation Agency (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 that will 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 as of searching for updates on the projects online, only the Smart SRP Development mostly

[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.
[6] Non-HUCs in Metro Clark and their income classes: Mabalacat City (3rd), and San Fernando City (1st)
[7] Non-HUCs in Metro Cebu and their income classes: Carcar City (5th), Danao City (3rd), Naga City (5th), and Talisay City (3rd)
[8] Non-HUCs in Metro Davao and their income classes: Digos City (2nd), Panabo City (3rd), Samal City (4th), and Tagum City (1st)

concentrated in Cebu City is in the works as of 2021. Given these results, it appears that online literature on smart city initiatives in non-HUCs of metropolitan are scarce. However, it is important to note that these results are not definitive, given that only a rapid online search was done.

Going back on the status of internet connectivity in other cities, as of November 2021, the Free Wi-Fi program of the DICT have already put up 11,475 free Wi-Fi facilities across the country (Rita 2021). Given the importance of internet connectivity in making the government response to the pandemic efficient, the implementation of the program was accelerated especially in terms of providing connections to geographically isolated and disadvantaged cities and municipalities (DICT 2021b). However, in a study done by ADB and Thinking Machines, there is still a huge disparity between the internet speed of the wealthiest cities compared to the poorest cities (Sy et al. 2021). The average internet speed in the wealthiest cities is up to 21 mbps faster than those of the poorest cities (Sy et al. 2021). Increasing internet coverage is important in bridging the digital divide among regions but 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 among the regions is the TECH4ED project of the DICT. As discussed in the previous section, the TECH4ED centers aim to provide more citizens with easier access to different information resources and services. As of 2020, there are 4,544 Tech4ed centers across 81 provinces in the country (PCOO 2021).

In terms of improving delivery of services, the implementation of the Integrated Business Permits and Licensing System (iBPLS) Project and Central Business portal (CBP) of the DICT has been instrumental in necessitating LGUs to digitize their systems. As of November 2020, 159 LGUs have already been supplied with the iBPLS-cloud system (PCOO 2021). A number of cities are also utilizing online applications for their Covid response efforts. The use of digital-based initiatives has become more critical especially due to the nature of the issue. Contactless measures are recommended to prevent further spread of the virus. While some LGUs developed their own contact tracing applications, some opted to adapt existing applications such as the *StaySafe.ph* application launched by the Philippine Government. According to a DILG official, around 700 LGUs are already using 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 instead adopt the *StaySafe.ph* app for easier overall tracking (DILG 2021). The need to unify the systems of LGUs is preferable in order for the pandemic to be managed more effectively (DILG 2021). In an effort to achieve this, the government is also now working on integrating the existing systems of LGUs (DILG 2021). The importance of having interoperable systems is highlighted here.

An increasing number of non-HUCs are also already crafting their own digital city roadmaps. For instance, the cities of Balanga, Batangas, Legazpi, and Tuguegarao have launched their digital city roadmaps this 2021 (Balinbin 2021). These were made possible with the help of the Digital Cities program of the DICT in cooperation with the Information Technology and

Business Process Association of the Philippines (IBPAP) and Leechiu Property Consultants (LPC) (DICT 2021c). The aim of this program is to foster development beyond the metro areas by helping the identified cities[9] prepare for the digital economy (DICT 2021c). Given these initiatives, it can be expected that more areas will be developing into smart cities.

6.7. Additional areas

Additional areas are notable in a Google search for smart plans and/or implemented smart actions in the Philippines. For instance, Cauayan City, despite not being in a metropolitan area, has been making waves in terms of implementing smart city initiatives. In the city, PLDT has rolled out fiber-powered fixed broadband network, 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 (Poon and Shiyuan 2019). The LGU has also set up LED screens near farms to provide weather updates (Poon and Shiyuan 2019). Additionally, Cauayan City constituents can use an application called "Cauayan City Connect!" for cashless payments, feedback, updates, emergency hotlines, and maps (Poon and Shiyuan 2019). Clocks are also synchronized by the LGU of Cauayan City (Poon and Shiyuan 2019). Cauayan City also planned to install kiosks for government-related payments (MultiSys Admin 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, Cavite 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 district cooling system (Mouton 2021). The interesting smart plans and actions of the areas encourage further reviews on the sites.

6.8. Missing link

The smart city initiatives of some LGUs in the Philippines are noteworthy, but the reviewed related literature on them do not establish the readiness of the country to have smart cities. Additionally, the LGU activities mentioned were discovered through the Google search engine generally using keywords including the name of the city, and "smart city" or "tech*". The extent of smart city development in each of the cities, therefore, might not be adequately represented. Furthermore, the progress of the mentioned smart city initiatives should be validated with the LGUs to update the findings laid out. A more in-depth review of the experiences of cities will also create an opportunity to determine suitable pathways in the implementation of smart city initiatives. The lack of research in the Philippine context on the drivers and extent of smart city development, and suitable pathways to take in implementing smart city initiatives will be dealt with in this research to establish Philippines' cities readiness to smart city development.

[9] 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, San Pablo), Laoag City, Legazpi City, Malolos City, Metro Cavite (Bacoor, General Trias, Imus), Metro Rizal (Antipolo, Cainta, 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. Case Study of Selected Philippine Cities

7.1. Initiatives

7.1.1. Cauayan City

The categorization of the Cauayan City LGU as having a high level of implementation of smart city initiatives was initially supported by data and information from online resources and later on by the shared documents of the LGU. Many of the initiatives are within the Infrastructure Phase, but there are also some initiatives within the Data and Service Phases (Annex 1). This subsection provides specific details on Cauayan City's initiatives to assess the extent of smart city development in the city.

Cauayan City LGU has established foundations of a smart city through its initiatives within the Infrastructure Phase (Annex 2). As early as 2014, it has already distributed WiFi routers to 65 barangays. Resolutions have also been issued from 2005 to 2019 on the installation of cellsites and/or expansion of cellular network system, as well as obtainment of WiFi services by the telecommunications company Smart. The LGU also worked with PLDT to install fiber optics in the city (Cabuenas 2019). There are also e-tricycles, some of which with solar panel on their roof, as well as a charging station (Almirol 2017). These were products of collaborations with stakeholders including the DOST, Isabela State University, and University of the Philippines (UP) Diliman (Almirol 2017). The DOST provided financial aid for the commercial viability (Almirol 2017). In 2017, the prototype models for the e-tricycles were paraded (Almirol 2017). Two chargers have already been installed for the e-tricycles (UP Diliman Electrical and Electronics Engineering Institute n.d.). E-scooters, equipped with an application for control and Global Positioning System for tracking, were also launched and obtained in a turnover ceremony in 2020 (PINAS 2020). For the project, a Memorandum of Agreement was made with the DOST, Isabela State University, UP-Electrical and Electronics Engineering Institute, and FILGENIUS (PINAS 2020). A total of 7 e-scooters were turned over to the LGU (Munchang 2020). In addition to the e-scooters, the LGU has a hybrid electric road train designed by the DOST – Metals Industry Research and Development Center and composed of four air-conditioned interlinked cabins that can fit 200 passengers (Domingo and The Manila Times 2019). It was launched and turned over in 2019 (Domingo and The Manila Times 2019). Another project is the Barangay Centralized WiFi Network equipped with Extranet, LAN Messenger, 5 gigahertz radio signal, and high sector antenna, enabling messaging and file sharing between and among barangays and the LGU (DICT et al. 2020). Through the project, 65 barangays became equipped with communication network and Internet (DICT et al. 2020). Additionally, the LGU has been implementing the Juan Time Campaign of the DOST, synchronizing time across devices and providing weather updates under the clocks (DOST 2015). There is also the waste-to-energy plant, backed up with a Memorandum of Agreement with Clean World Sustainable Solutions Inc. and other Metro Cauayan and Isabela LGUs, generating energy using waste products from Cagayan Valley (Domingo 2016). Another initiative is deployment to geographically isolated and disadvantaged areas of RxBox, which was donated by Ionics EMS, Inc. to DOST, enabling the measurement of heart rate, oxygen saturation, and temperature (Dig 2021). 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, Isabela State University, DOST, CHED, and Dynamic Outsource Solutions Inc. (Domingo 2021). Additionally, the LGU has worked on an IoT-based

aquaponics with the Temasek Polytechnic University and Isabela State University, and 160 households in Sitio Manalpaac were given livelihood assistance. A water quality testing laboratory was also set up and whose establishment was supported by a Resolution involving the DOST and Isabela State University. The discussed Cauayan City initiatives are expected to build the foundation of a smart city.

In terms of the Data Phase, there are also numerous initiatives in Cauayan City (Annex 2). These initiatives include the PATURO which consist of a data hub linked to a visualization platform to derive insights on the transport network (DOST-PCIEERD 2020c). The project is financed by the DOST-PCIEERD and launched in 2020, and project implementers are the Asian Institute of Management and Isabela State University (The Manila Times 2020). Another 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 2021j). As a contract tracing effort during the COVID-19 pandemic, QR Codes are generated with the help of Nspire Inc. and AJ Enterprises, and required for constituents (Dig 2020). In addition, the LGU has a digital twin, which is 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 Singaporean startup company Graffiquo (Tan 2021). According to the head of the LGU drone team Cornelius Dalog II, 0.5 square kilometer of waterfronts were captured in two days and 3D landscape models were created (Graffiquo 2020). The LGU also has an Investment Website presenting investment opportunities and the incentive package (see Cauayan City Economic and Investment Promotion Website 2019). Cauayan City's initiatives reflect the value it places on data.

Service Phase initiatives also exist in Cauayan City (Annex 2). Some drones are deployed to keep constituents safe, capture criminals, and implement lockdown restrictions. In 2019, Barangay Cabaruan became equipped with a drone (Brgy. Cabaruan 2020). Three drones were also deployed in Cauayan for the monitoring of constituents during the COVID-19 lockdown (Visaya 2020). Through a partnership with the Multisys Technologies Corporation, the Cauayan City App was developed, enabling 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, which is a product of a collaboration with GCash, also went through different versions from a simple ID in 2014, an ATM-enabled one in 2015, and a Mastercard-enabled one in 2018. 5,000 IDs were reported to have been distributed already. Kiosk machines have also been deployed to facilitate bills payment. Additionally, a Smarter Dengue Early Warning System has also been implemented through the release of an app and information mapping. The initiatives within the Service Phase are expected to reduce the burden of the COVID-19 pandemic.

Initiatives are assessed in terms of the working definition of this study (Annex 1). Most of the initiatives involve processing and communicating of data and information. In terms of focus areas, many of the initiatives are concentrated on built infrastructure. Additionally, many deal with the collection and provision of data and information by, from, and/or to institutions. The target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.2. Tuguegarao City

Tuguegarao City has smart city initiatives based on online resources and shared documents of the LGU. Many of the initiatives are within the Infrastructure Phase, but there are also some initiatives within the Data and Service Phases (Annex 3). This subsection provides specific details on Tuguegarao City's initiatives, enabling assessment on the extent of smart city development in the city.

Tuguegarao City has some initiatives within the Infrastructure Phase (Annex 4). These initiatives include the Free Direct Internet from Globe Business, enabling connection between offices for needs in video application, voice, and data (Amojelar 2019). There is also free WiFi in some public areas, equipped with fiber optic wide area network. In addition, the MyCure System is made available in partnership with the DOST to facilitate online medical consultations. There are still numerous opportunities in the Infrastructure Phase that Tuguegarao City is treading.

In terms of the Data Phase, the LGU has some initiatives (Annex 4). The Command Center has been established as a real-time monitoring center with CCTV and is operated with the Philippine National Police and Bureau of Fire Protection (Tuguegarao City Government 2021a). The Tuguegarao City LGU has been working on coming up with a digital twin with the support of the Cauayan City LGU (Yun Xuan 2021). Data collection is apparently involved in the initiatives mentioned.

There are also some initiatives in the Service Phase (Annex 4). These include the efforts associated with the Tuguegarao Government Portal. The portal provides access to online government services such as Travel Pass Application, Checkpoint Registration, QR Card for Non-Residents, Online Payment and QR for Residents and Non-Residents, and Vaccination Registration (Tuguegarao City Government 2021b).

The initiatives are assessed in terms of the working definition (Annex 3). Many of the initiatives involve processing and communicating data and information. Safety and security, and civic and social are major focus areas. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to institutions. The target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.3. San Fernando City

San Fernando City has smart city initiatives based on online resources and shared documents of the LGU. Many of the initiatives are within the Infrastructure Phase, but there are also some initiatives within the Service Phase already (Annex 5). This subsection provides specific details on San Fernando City's initiatives to assess the extent of smart city development in the city.

Based on the shared LGU documents and online resources, most of the initiatives are within the Infrastructure Phase (Annex 6). These include the Free fiber-powered WiFi in the City Hall and Old Public Market, a donation made possible through a Memorandum of Agreement with the Smart Communications Inc. in 2019 (SunStar Pampanga 2019a). Fiber optic cabling has also been included in the Smart City Phase II Program, made possible through a loan from LandBank of the Philippines and given an allotment of PHP 100 Million in the 2021 Annual

Investment Program. The LGU has also provided free WiFi in 9 Early Childhood Care and Development Centers. Another initiative is the integration of the systems used in inter-office transactions. Solar panels are also installed to serve as additional energy source.

Within the Service Phase, the initiatives are the Command and Control Center and online business registration (Annex 6). Mayor Edwin Santiago relayed that the PHP 220 Million financing for the Command and Control Center, which was inaugurated in 2020, came from 2018 LGU savings and business sector (Arcellaz 2020). There are considerably numerous recorded outputs under the initiative like 110 bullet cameras and 26 video walls. Another initiative is the online business registration, available with an option of delivery service (SunStar Pampanga 2019). According to Business License and Permit Division Chief Joseph Garcia, Resolution No. 2018-024 was issued for a Memorandum of Agreement with 2Go Express Inc. (Sunstar Pampanga 2019b).

The initiatives are assessed in terms of the working definition (Annex 5). Many of the initiatives involve processing and communicating data and information. Built infrastructure is a major focus area. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to institutions. Furthermore, the target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.4. Malabon City

Malabon City has smart city initiatives based on online resources and shared documents of the LGU. Although with low level of implementation, most of their initiatives are in the Service Phase (Annex 7). Initiatives in the Infrastructure Phase include the upgrading of 101 cell sites and installation of six new ones for 4G connection (see Globe 2021) (Annex 8). Within the Data Phase, there is the installment of CCTV cameras for emergency monitoring and response, financed through an internal budget of around PHP 9.99 Million and went up for bidding in 2017 (see Malabon City Bids and Awards Committee 2017) (Annex 8). Meanwhile, included in the Service Phase is the GIS-complemented computerization of tax collection data and transactions in revenue-generating departments (Melican 2013) (Annex 8). It was financed through an internal budget amounting to PHP 3.8 Million, inclusive of software license, deployment and setup of equipment, and training (Melican 2013). In addition, the Malabon City LGU developed a contact tracing application with QR code technology integrated into the City Health Monitoring System (David 2020b). There is also an initiative for online transaction payments, supported by a 2020 contract signing with IB Solutions IBS Worldwide Corporation (Lim 2020).

The initiatives are assessed in terms of the working definition (Annex 7). Many of the initiatives involve processing and communicating data and information. Built infrastructure, and civic and social are major focus areas. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to people and institutions. Furthermore, the target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.5. Mandaue City

Mandaue City has smart city initiatives based on online resources and shared documents of the LGU. Relatively more initiatives are within the Infrastructure and Service Phases (Annex 9).

This subsection provides specific details on Mandaue City's initiatives to assess the extent of smart city development in the city.

The LGU has initiatives within the Infrastructure Phase including the Asia-Pacific Economic Cooperation (APEC) Low Carbon Model Town Project, solid waste management, additional solid waste management technologies, and the installation of fiber broadband connection (Annex 10). 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 is the development of the Green Building Program, solid waste management technologies, and modelling of urban heat islands. The LGU has invested in the project through their Annual Investment Program. The initiative is also supported by the Green Building Ordinance of Mandaue City. In line with the environmental agenda of Mandaue, the DENR – Environment Management Bureau (DENR-EMB) signed a MOA supporting the donation of 13 units of rotary drum composter, biodegradable waste shredder, and solar-powered 4G network camera kit (DENR-EMB 2021). Bike repair stations, financed by Vivant Foundation, are also being installed in Mandaue City (Sagarino 2021). A Tripartite MOA with Vivant Foundation and Mandaue Chamber of Commerce and Industry have been signed in 2021 to support the installment (Sagarino 2021). In terms of connectivity, the LGU has partnered with Converge for the deployment of fiber broadband services (Diangson 2021).

The Data Phase covers the Traffic Management System and Purok Database System (Annex 10). CCTV cameras and sensors have been reported to be obtained back in the 1990s (Talisic and Sotto 2018). In 2013, Mandaue invested at least PHP 79 Million for digital clocks and high-definition cameras along 13 major intersections (Talisic and Sotto 2018). Traffic lights were planned to be installed costing PHP 5 Million (Talisic and Sotto 2018). Furthermore, a Proof of Concept agreement has been entered into with Dyna-Tech and HUALU e-cloud for the development of a no contact apprehension system (Palaubsanon 2019). Another initiative within the Data Phase is the development of a Purok Database System, which has been allotted a total budget of PHP 12 Million from the 2021 Annual Investment Program.

Within the Service Phase, there are also some initiatives (Annex 10). The Guardian Emergency Response System consists of a free mobile application for reporting of incidents or requesting assistance, and a software for dispatch and deployment (SunStar Cebu 2018). A MOA was signed with the software developer Sugbotek Inc. for the adoption (SunStar Cebu 2018). Another initiative within the Service Phase is the Electronic Business Permit and Licensing System, which enables the online processing of business permits accompanied by a QR code and security sticker for authenticity validation according to Business Permit and Licensing Office head August Lizer Malate (SunStar Cebu 2021). The system was launched in 2021 (SunStar Cebu 2021). It has been developed with the DICT (Mandaue City Government and DICT n.d.).

The initiatives are assessed in terms of the working definition (Annex 9). Many of the initiatives involve processing and communicating data and information. Initiatives are spread out across civic and social, safety and security, built infrastructure, and quality environment focus areas. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to people and institutions. Furthermore, the target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.6. Davao City

Davao City has smart city initiatives based on online resources and shared documents of the LGU. Many of the initiatives are within the Infrastructure Phase, but there are also some initiatives in the Service and Data Phases (Annex 11). This subsection provides specific details on Davao City's initiatives to assess the extent of smart city development in the city.

The LGU has initiatives in the Infrastructure Phase (Annex 12). These include the High Priority Bus System. According to DOTr Secretary Arthur Tugade, 626 kilometers of road network will be covered in the system (Dela Cruz 2021). Involved in the capacity building for the planning, regulation, implementation, and monitoring are the DOTr, LTFRB, and LTO (DOTr 2019). The project has been financed by the Asian Development Bank for the consultancy of GHD Pty Ltd. (Davao City Government n.d.-a). There are three modes in which the PHP 18.66 Billion from Official Development Assistance is allotted: Public Transport System Improvement, Program Institutional Capacity Strengthening, and Social Development Program) (DOTr 2019). The project has also been approved already by the NEDA Investment Coordination Committee in 2019 (DOTr 2019). DOTr Secretary Tugade relayed that the target date of completion is on the third quarter of 2023 (Dela Cruz 2021). Ordinances have also been issued involving the social development and the Livelihood Restoration Program associated with the system. Aside from the High Priority Bus System, Davao City is also working on the Underground Distribution System, a project being conducted with the Davao Light and Power Company, requiring the removal of dangling overhead wires (Padillo 2021). The first phase was completed in 2017 with the removal of underground cables along the downtown area surrounding LGU buildings (Francisco 2018). According to a DLPC official, the second phase of the project involves six circuit kilometers of overhead lines and would cost PHP 1 Billion (Francisco 2018). Ordinances have been enacted to place the cables underground and to require compliance with the plan. Another initiative in the Infrastructure Phase is the use of the RT-PCR Machine donated by DOT. The city is also connected through fiber optics deployed by the PLDT (Llemit 2020). The LGU also has been able to use a technology that converts used cooking oil to biodiesel fuel (Carillo 2017). The technology was acquired through a collaboration with the Japanese government; Japan International Cooperating Agency; Shinozaki Transport Warehouse Co., Ltd; and the technology manufacturer Biomass Japan, Inc. (Carillo 2017). It was able to produce 1,800 liters of biodiesel fuel during the launch in 2017 (Carillo 2017). Another initiative is the Davao City Disaster Radio that started going on air in 2020 and gives information on disaster preparedness and LGU activities (Davao City Government 2020). There has been a plan to involve the entire Davao region through a partnership with Region XI governors, and some governors already signed a manifesto to symbolize their support for the radio (Davao City Government 2020). The Armed Forces of the Philippines has also signed a Memorandum of Agreement in relation to the relaying of disaster preparedness-related information (Davao City Government 2020).

There are also some initiatives within the Data Phase (Annex 12). One of them is the No Contact Apprehension Project, a PHP 0.0495 Billion project under the PPP Center and whose private sector proponent is the Qpax Traffic Systems Inc., involving the installation of traffic enforcement cameras for the detection of traffic violations (PPP Center n.d.-d). Davao's Public Safety and Security Command Center has already facilitated the deployment of 190 surveillance cameras (Development Academy of the Philippines [DAP] 2020). Mobile access of constituents to Central 911 was supported through engagements with Sun Cellular, Smart Communications, Globe Telecom, and PLDT (DAP 2020). The LGU has been importing the COVID-19 vaccination data to a system according to Mayor Sara Duterte-Carpio (Llemit

2021). The development of a COVID-19 Electronic Immunization Registry is under an Ordinance on the implementation of the COVID-19 Immunization Program of Davao City. Another initiative within the Data Phase is the issuance of public utility vehicle drivers' identification cards with QR codes to help in traffic violations reporting (see Canedo 2018). Davao City Transportation and Traffic Management Office head Dionisio Abude relayed that around 19,000 identification cards have been released, and apprehension for the drivers without IDs would start in 2018 (Canedo 2018).

Within the Service Phase, there are also initiatives. Central 911 offers a system that connects constituents to nearest emergency responders (Davao City Government 2018a) (Annex 12). The LGU collaborated with the Davao Light and Power Company initially in 1997 for the Davao City Street Lighting Project, and the outputs included light poles that can be located through GIS (DAP 2020). An engagement was also made with the Davao Light and Power Company for the Emergency Computer-Aided Dispatch for Central 911, which was launched in 2002 (Center for Health Market Innovations 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 in times of emergency (Cantalejo 2013). Another initiative is the Safe Davao QR, a platform for travel pass and contact tracing (Davao City Government n.d.-b). Ordinances were issued on the mandatory implementation of Safe Davao QR. In addition to the mentioned initiatives, the LGU has also enabled online application for business permits through its website (Davao City Government 2018b). The LGU has also worked on an Electronic Halal Hub Trade Facilitation Platform for halal products of Mindanao small and medium enterprises, partnering with data technology firm Fusionex International (Padillo 2020). An Ordinance was issued for the Non-Disclosure Agreement with Fusionex.

The initiatives are assessed in terms of the working definition (Annex 11). Many of the initiatives involve processing and communicating data and information. There are relatively more initiatives within the focus area of built infrastructure. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to institutions. Furthermore, the target of most of the initiatives is perceived to be the attainment of high quality of life.

7.1.7. Tagum City

Tagum City has smart city initiatives based on online resources and shared documents of the LGU. Many of the initiatives are within the Infrastructure Phase, but there are also some initiatives in the Data Phase (Annex 13). This subsection provides specific details on Tagum City's initiatives to assess the extent of smart city development in the city.

The LGU has initiatives within the Infrastructure Phase (Annex 14). The Revenue Administration and Mobilization Program is envisioned to be an automated and integrated management system, and a loan was made with the Development Bank of the Philippines. The LGU also installed Integrated Systems Digital Network and Private Automatic Branch Exchange for City Trunkline to facilitate communications. This was made possible through the LGU's internal budget and a loan. Smart solar-powered street lighting is also being installed. EURO 4-compliant heavy equipment and vehicles have been acquired to reduce greenhouse gas emissions. There is also a Waste-to-Energy Plant Project under the PPP Center (PPP Center n.d.-b). The project costs PHP 757.61 Million, and the private sector proponent is the Global

Green International Energy Philippines, Inc. (PPP Center n.d.-e). Expected to contribute in the Infrastructure Phase is Hijo Resources Corporation's Hijo Central. According to Ms. Rosanna Tuason-Fores of Hijo Resources Corporation, the developer of the project, Hijo Central is envisioned to be a smart city – a hub of biotech, agritech, and foodtech (Alama 2019). The Tagum City LGU will be working with Hijo Resources Corporation in constructing an intermodal transport to be connected to Hijo Central (Alama 2019).

Within the Data Phase, there are also some initiatives (Annex 14). These include the Traffic Signalization and No Contact Apprehension. Related activities include the installation of traffic lights in priority junctions (Tagum City Government 2018). They also include the establishment of traffic surveillance cameras and monitoring of traffic violations. The Traffic Signalization Project is financed through a loan with the Development Bank of the Philippines, and it was contracted out to the Traffic Supplies & Construction Corporation. The LGU also uses LED walls, television, radio, and print and social media to disseminate information.

The initiatives are assessed in terms of the working definition (Annex 13). Many of the initiatives involve processing and communicating data and information. There are relatively more initiatives within the focus areas of built infrastructure, and civic and social. Many of the initiatives deal with the collection and provision of data and information by, from, and/or to institutions. Furthermore, the target of most of the initiatives is perceived to be the attainment of high quality of life.

7.2. Interview Themes [10]

7.2.1. Smart City Definition

Word frequency query was conducted using NVivo11 to find out the top 100 descriptive words that were mentioned by the respondents when asked about their definition of a smart city (Figure 5). Among the top 10 descriptive words were: development, local, digital, sustainable, public, private, quality, social, good, and online. Each word was mentioned more than 400 times across all interviews conducted.

Based on the interviews, there is still no universal definition of smart city that is being used in the country. Definitions coming from the NGAs were usually adopted from different development frameworks here and abroad. Most of these frameworks usually have various focus areas which lead to variations in definitions. Moreover, every NGA has their own mandate which dictate the extent of their participation in the implementation of the projects at the national level. One NGA shared:

> *"… 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)"* – Interview with DILG

[10] Some quotes in this subsection have been translated in English.

Figure 5. Most frequent used word to describe smart cities during KIIs

Source: KIIs – Authors

For the LGUs, they usually define smart city as efficient use of technology to improve service delivery, public safety, and sustainable development and environment. For them, the overall outcome they want to achieve from this endeavor is to improve the quality of life of their people. In fact, one of the respondents shared that LGUs do not realize yet that they are already implementing smart initiatives in their city. They just do not label it as such. As one LGU shared:

> *"... LGUs are already doing smart city projects, they just don't know it. So, it's just a matter of making them understand the smart city framework and how they can incorporate whatever they're already doing and they already have, in that kind, in that framework. So, yeah, it's not a grand vision to become a smart city. Cauayan City, you know, is a perfect example that you don't need to be in a highly urbanized area or a metropolitan area. You don't have to be a rich LGU to be a smart city*." – Interview with Cauayan LGU

Moreover, there are already various KPIs and frameworks readily available to the LGUs to use. Also, the respondent pointed out that initiatives don't have to be grand or highly complex and technical for it to be considered as a smart city initiative. The important aspect of it is that this technology was able to address the needs of the people.

For private partners interviewed, their definition of a smart city was a city that is taking advantage of the technology to ensure economic growth and sustainable environment. Development organizations interviewed define their role as 'making cities future-ready' thru efficient use of available technology to address their specific issues.

Moreover, they noticed that the level of readiness to smart city varies across national agencies and LGUs. One respondent from the development organization believes that there is a need to connect the different smart city initiatives because they noticed that each stakeholder engages with SC initiative depending on their vision or priorities. This will avoid duplication of initiatives.

7.2.2. Motivations

Annex 15 describes the motivations shared by the respondents during the interviews. Majority of their responses were categorized under provision of high quality of life, addressing public issues, support informed decision making, support development and sustainability, replicate best practices, CSR, and business prosperity.

Key informants were asked what motivates them to implement smart city projects. For the LGUs, their main driver is to be able to deliver high quality of life to their constituents by improving their service delivery, making cities more livable, sustainable environment, and developing a competitive economy/business-friendly city. For them, improved service delivery can be as complex as using high tech equipment like sensors, high-definition CCTV cameras, and drones, but it can also be as simple as providing timely weather report for farmers. Some LGUs wanted to showcase that even non-urbanized or agricultural cities can develop into smart cities.

To uphold the policy of Ease of Doing Business and alignment with the Local Government Code, LGUs engaged in projects that will digitize transactions in construction and business permits, contactless transactions, PhilHealth claims, tuition fee payments to improve their service delivery. Provision of these services to their constituents will eventually lead to improving the high quality of life in terms of health and well-being, public safety, competitive economy, livable and sustainable environment.

LGUs also shared that they engage in SC initiatives because they believe that it will help them in planning and responding to the needs of their people. These initiatives allow them to collect and analyze data for the LGUs to make informed decisions especially in times of disaster and pandemic.

Public issues urge LGUs to explore ways to address these led them to engage in smart city initiatives. Some of the key areas mentioned were on disaster risk response, public safety, transportation, or traffic issues, etc. The COVID pandemic allowed the LGUs to realize the need of using technology to be able to collect the necessary information that will allow leaders to have informed decisions.

LGUs also shared that they wanted to capitalize the available resources for promoting better life in the cities. For example, Tagum LGU shared their “Transformative Mindanao” concept that promotes their city and/or region by revolutionizing agriculture in Tagum and the rest of Mindanao. They are also keen in establishing “cleaner” Tagum City by establishing infrastructure support for e-vehicles. San Fernando City focused on providing fiber connectivity in their city for better service delivery. Mandaue City have shared several projects

that were focused at providing renewable energy at far-flung areas and promoting recycling to produce alternative fuel source for construction businesses.

Partners from the business and development organizations also shared their driver in engaging with smart city initiatives with LGUs. One of the drivers for business partners in SC initiatives is for their CSR. Some private partners interviewed provided free technical assistance, shared company assets free for use especially in times of disasters and COVID response, etc. They also find this an opportunity to maintain good working relationship with their city and clients.

Business partners highlighted the importance of protecting their clients as well as the community that they are situated for business prosperity. They see engagements in smart city initiatives with LGUs as opportunities to become corporate citizens and serve the underserved. Also, some business partners use phrase like: "good for the people or city, good for the business".

For development organizations, they assist LGUs in addressing pressing issues in their respective areas in line with the objectives of their organization. For example, one of the organizations assisted an LGU to address waste management by tapping an international SME technology. Some development organizations also assisted an LGU in modelling their city roads using technology they developed. Another development organization highly supported an LGU on its ICT-related projects to improve the business sector. A development organization also worked with the academe in establishing an innovation hub to ensure that start-ups were supported and to address SDG No. 8. Meanwhile, one of the organizations supports ensuring that development will not compromise the environment.

On the national level, NGAs shared that they want to ensure that public issues are addressed at the national level. It is good to note that NGAs have different mandates and their motivations were aligned to those mandates. Some of the issues that were highlighted were: achieving SDGs (DOST-PCIEERD); upholding the data privacy act (NPC); ensuring that cyber security (DICT); establish better internet connectivity, provision of free WiFi access, and other ICT-related assistance in COVID response (DICT); improving the processing of business requirements and licensing (DILG), addressing climate change, aligning infrastructure developments to national development plans (PPP Center), and disaster risk reduction measures and responses (PPP Center).

NGAs also noticed LGUs' autonomy to decide on initiatives. As observed by one of the NGAs interviewed:

> *"… (W)hat I learned also is that local governments also have this aspiration to be innovative and then they also want to have this kind of positioning where they are also innovators…. they also want to publicize that they were also first in that kind of pursuit. You'll be surprised. That's how competitive they are. But, for most of them, it's seeing to it that it addresses their particular concern in local government."* – Interview with DOST-PCIEERD

NGAs also value the importance of learning the best practices here and abroad to serve as model in implementation of smart city initiatives in the country. Participation in different smart city network organizations not only provide policy blueprint for Philippine cities to adopt, but

also open opportunities for funding assistance through grants. LGUs that have been exposed in the success of smart cities abroad also motivates them in learning more about smart cities and how they can apply those in their hometowns

Other motivations mentioned by respondents were about increasing connections or network here and abroad and improving the monitoring and evaluation of different national programs.

7.2.3. Enablers

This section describes the enabling factors for the implementation and success of the smart city initiatives from the respondents' perspective. Some of the key enabling factors mentioned were partnership with other agencies, compliance with existing policies and guidelines, seeking certifications, existing ICT department or staff, having smart city champions, access to technology, and existing infrastructures (Annex 16).

Partnerships

For LGUs, one of the main enabling factors is their engagement with other agencies. Partnership with private sector and NGAs allow LGUs to learn from them as well as utilize their technology, systems, and even funding to implement smart city projects that will improve their 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's very important to get everybody on board and you'll eventually get a lot of solutions providers also that would want to partner with you. That will make it sustainable."* – Interview with Cauayan LGU

For the private partners, they value the strong partnership with LGUs as the main enabler for the development of smart city initiatives. They perceive the LGUs as their biggest stakeholder, hence, the success of any smart city project relies with the willingness of the LGUs.

At the national level, NGAs see the importance of a multisectoral approach in implementing smart city initiatives. These partnership with different NGAs and international organizations were important for funding support.

The availability of funding opportunities from national agencies like DOST-PCIEERD on smart city opened opportunities of using the best practices from successful smart cities abroad and use it in the country. Aside from funding support, NGAs also provide technical support thru consultations provide to the LGUs. DICT, DOST-PCIEERD, and PPP Center for instance, provide technical assistance for different concerns nationwide if LGUs reach out to them.

They also see the major role of universities as training ground to develop smart people for smart cities. Hence, they see the importance of the strong partnership among these institutions for smart city projects to be successful. Constant communication among stakeholders build trust which ensures the partnership. This will also ensure that initiatives do not duplicate efforts. Availability of information about which priority areas where development organizations and even business partners can look into so they know what are the priorities of their potential partners. Examples of these are availability of feasibility studies or even development plans of the city will help them identify projects that they can offer to LGUs.

Compliance with existing policies and guidelines

National policies, laws (eg. Local Government Code), and guidelines nudge LGUs to engage in smart city projects. This is also seen as enabling factor for NGAs as they see more participation from LGUs complying to different RAs, national guideline, programs, roadmaps, and frameworks. Some LGUs even assign people to keep track on upcoming guidelines that they need to abide with to better serve their constituents. According to one participant, one of the first services that was required by law to be computerized was the business permit licensing. This law provided support in hiring ICT personnel to develop and implement this. Later, other services were also digitized. After the funding from the national government ended, they institutionalized the ICT department via ordinance for the systems to be sustained. This can also work at the local level wherein executive orders or ordinances ensure compliance from the public but also the commitment of their partners.

Policies and ordinances encourage compliance from private partners. This is especially true in projects that require massive infrastructure developments.

Seeking certifications

Compliance for certifications like ISO and BERDE required LGUs to apply smart city initiatives in their governance. Seeking ISO certification led them to think of ways on how to digitize and streamline their processes. BERDE certification, on the other hand, ensure that all infrastructure projects do not compromise the environment.

Assigned ICT department or staff

LGUs with designated ICT department or personnel can lead to better utilization of ICT technology and systems to improve service delivery. These personnel are not only on the lookout for technological advancements and updates but they can also advocate the use of the available technology to the LGUs. Continued capacity building of these trained personnel or department are also seen necessary for the success and sustainability of the projects.

Engagement with of private partners can be encouraged when LGUs have digitized data or when there are feasibility studies previously conducted. Private partners can see potential reduction of costs when these systems are already in place in their prospective partnership with LGUs.

Smart City Champions at LGU level

SC champions especially at the Executive side of the LGU government were seen important factor the ensure smart city engagement of the LGUs. Without this vision and will/commitment, LGUs may not engage with business partners or simply do not approve projects branded as smart city.

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

Leaders with strong willingness and commitment to SC initiatives attracts the business sector since these projects require big investments. One of the private partners interviewed shared what encouraged them in pursuing SC initiatives:

> *"I think it ranges from LGU to LGU. And Mandaue is one of the forward ones in Cebu. I think it all comes down to the leader. There is no general statement, but what we have noticed is that when you have the leadership that is really pushing for progress, sees the value in new methods and technologies, the development come much faster."* – Interview with business partner

Aside from that, strong working relationship was described as teamwork/collaboration between LGUs and business partners. Both deliver their roles as expected. Alignment of their objectives are also seen as important factor to establish this strong working relationship.

For the development organizations, they value SC Champions at the LGU level as main enabler of a successful SC initiatives. This is also a major factor in the sustainability of SC initiatives. One respondent mentioned:

> *"The main factor, actually, would be the genuine interest of these LGUs. Because without this, it's really difficult. So, for example, for Cauayan City, Mayor Dy is really driving the smart city readiness of Cauayan City. And we can see that. So, he's very much interested, we are very much interested. So, this ignited this cooperation."* – Interview with a development organization

<u>Accessibility to technology</u>

Access to wide variety of technology allowed LGUs to explore various ways to communicate with their constituents. Available ICT infrastructure at LGU also give LGUs leverage especially when in engaging with private partners for implementing projects. Majority of LGUs interviewed have the necessary ICT infrastructures like sensors, reliable internet connection, including offices that necessary to collect and maintain these systems. Majority of these initiatives were borne out projects in partnership with private sector and national agencies. Availability of digitized data also entice private partners and NGAs since they can readily use or import existing databases to their systems or applications.

LGUs with ICT team/department facilitate implementation of SC projects entice engagement from the private sector. It also makes engagement with other national agencies much easier. Also, these joint venture among LGUs and private partners including universities, allow access to the available technology/systems for the LGUs for free or with minimum charge. Technology purveyors provide the technology to the LGUs which they can tap to address issues relevant to them.

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

7.2.4. Challenges

Respondents were asked about the challenges or issues they have in implementing smart city initiatives. The topmost cited issues were lack of interoperability and operational costs. Annex 17 describes the common themes raised by respondents during the interviews.

One of the most cited challenge was the lack of funding for these initiatives, particularly in setting up the necessary ICT infrastructure and systems where these initiatives will operate. While majority of the interviewed LGUs have existing basic ICT infrastructure, the fast-paced growth of the technology industry requires these LGUs to continuous upgrade their systems which can be very costly. One of the LGUs shared that they have been approached by different service providers for COVID dashboard, however they find these pre-developed systems too costly. To add, a few LGUs interviewed shared that they still use paper-based records and old versions of hardware like computers for some of their barangays due to lack of funding. Some of the cited upgrades that needs to be done but requires huge budget were hardware, internet connectivity to fiber optics, early warning systems, communication devices, and sensors or CCTV cameras. Even the need of physical buildings to host these systems not to mention train and hire staff to maintain and manage these systems were also found to be costly for LGUs to implement alone. The private partners also consider lack of infrastructure as a challenge since most of their systems would require fast reliable internet, physical space and buildings, and trained people to operate, manage, and maintain the systems.

This lack of funding led LGUs to rely heavily on partnership to fund these initiatives. Some LGUs mentioned some of their experiences that some initiatives did not materialize due to their reliance with private partners. Moreover, respondents also see the lack of network connections with other private partners where LGUs can explore partnership and seek funding support. One NGA mentioned that this has led to a vendor-driven development of the cities.

Second most cited challenge was the lack of interoperability of the systems. LGUs mentioned that most of the systems work in silos. Each project or initiative has its own way of data collection and storage which often makes data collation tedious especially in times of disaster or pandemic. This differences in systems might be brought upon by different priorities of requesting offices and partnerships with different service providers.

While there are existing efforts in collecting data, lack of data was still seen as challenge by the respondents. Private partners and NGAs recognized this as they have shared issues on data cleaning and merging datasets because it entails more time and resources. Moreover, data reliability was also mentioned. One specific example shared by San Fernando LGU in terms of data was: *"…if we need the data of how many establishments, etc…, we need to ask to different offices. Then, sometimes you still have to compare the datasets for verification."*.

The public uptake of these smart city initiatives was also considered as one of the challenges, especially for the LGUs. Many LGUs mentioned that public's ability to adapt to technological innovations remains a constant but manageable issue. LGUs reckon that the public need certain amount of time to understand the purpose of the initiatives and learn the ropes. This challenge was also cited by some private partners and NGAs but the reason was more on the context of lack of public trust on how the data collected will be used and stored. Aside from public uptake, some of the offices within the LGUs wherein staff are having issues especially during the ISO certification. They have seen this during the implementation of certain initiatives, particularly

in business permits application, real tax payment services, Rules on Administrative Cases in the Civil Service 2017, delivery of social services, PhilHealth claims, contact tracing, and traffic rules and regulations.

In relation with social acceptance, digital divide was also included in the list of issues that was mentioned by the respondents. At the individual level, digital literacy was mentioned as factor that contribute with lack of social acceptance. Examples shared include experiences in implementation of online payment services, telemedicine, and contact tracing which many target participants failed to utilize due to 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.

Next issue that was mentioned by respondents were on the lack of policies and standards. NGAs like PPP Center and NPC highlighted the role of national or even regional framework integrating initiatives. Specifically, NPC highlighted the need for data sharing guideline, while PPP Center wanted to see a framework that will ensure interconnectivity and interoperability among different smart cities and their initiatives. Some LGUs also see the need of such regional or national framework or guidelines which can help them in planning and prioritize projects. San Fernando LGU raised this issue leading them to have a hard time consolidating it into one action plan:

> *"… (S)ometimes, it is being discussed in a meeting but there's no reference. The only reference you can use is the minutes of the meeting. You can't really translate it into one action plan."* – Interview with San Fernando LGU.

While there are existing policies, respondents also shared that some of these policies are not implemented properly, compounding difficulties in implementing smart city projects. Taking on the perspective of the partners, there were some issues in the implementation of segregation policy that they coordinated with their LGU to strengthen their information drive to address the issues on timely collection and segregation at the MRF sites.

The misunderstanding of the Data Privacy Act across different level poses issues. On the perspective of the LGUs, the policies on cybersecurity and data privacy prevent them to collect more data. Hence, LGUs opted to become protective over their data, which can become an issue at the national level wherein there is a need to consolidate certain information, to cite specifically, the contact tracing initiative.

Another issue that was cited by majority of the respondents was the change in administration. This is a particular concern for the private partners because they perceive changes in leadership means changes in priorities which can threaten existing projects, especially if these projects are yet to be institutionalized by and ordinance. LGUs also recognize this issue since implementation and funding support for smart city initiatives rely heavily in the priorities set by the incumbent leaders. On the national level, NGAs noticed that changes in leadership can redirect the priorities of LGUs, threatening the sustainability of existing projects. This would mean they need to start engaging them again in smart city initiatives implemented at the national level. And with the looming national election, one respondent from the NGAs sees danger that the uptake of these technologies can be used for political interests. Aside from the

danger that databases, the sudden surge of implementing smart city initiatives to increase a politicians' digital presence can be used for campaign purposes and not with its intended use.

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

The private partners saw bureaucratic processes like securing of permits and other requirements from different offices as additional cost. Some business partners mentioned issues like the time it takes for these requirements to be secured and red tape as issues that impose additional costs for the projects. One participant shared that the business sector deems some regulations as hoop since they cannot see the relevance of such policy 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.

7.2.5. Pathways

Respondents were also asked about the pathways in which LGUs, private partners from the business and development organizations can take to initiate smart city projects. The most cited effective pathways that they mentioned were the following: engagement in PPPs with formalized agreements, capacity building, implementing pilot projects, and information and dissemination (Annex 18).

Formalized PPPs

Partnerships with different agencies was considered one of the pathways to successfully implement smart city initiatives. LGUs have been engaging with the business sector, development organizations, state universities, and national agencies to augment funds, access technology or systems, equipment, and training for them to implement initiatives. DICT and other telecos provide support for the implementation of Business Permits and Licensing System. A local ICT supports its city in developing an app-based emergency reporting system that connects to the different response team including volunteer groups. Initiatives that involve huge infrastructure investments were materializing with the help of business partners. And with the impending implementation of Mandanas ruling, LGUs will be collaborating with private partners to address the additional task the policy entails. The PPP Center shared:

> *"…(W)e anticipate more local governments tapping the PPP mode. Because yes, they have a greater budget but that includes a greater scope of responsibilities. And a lot of those… it might not be … a lot of the local governments may not have the sufficient capacity to undertake everything. So, we do see them tapping more private sector partnerships in order to diversify how they provide their services."* – Interview with PPP Center

Some LGUs shared that their partnership allows them to touch base with international agencies where they can also seek assistance thru grants. Creation of SC Belt allows regional development and avoids duplication of projects. One development organization deemed partnership as one way to address financial concerns in implementing smart city initiatives, sharing that:

> *"One city is unable to do everything. One city will have resource limitation. Funding limitation. What we do is spread out."* – Interview with development organization

These partnerships are often strengthened by formalized agreements. In fact, most of the respondents mentioned that MOAs are pre-requisite for an initiative to take place. Issuance of ordinances were also seen to ensure that projects will 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 imitative, which is a foundation of a good partnership. This documents also provide assurance that donated funds from international organizations were used accordingly in the proposed smart city projects.

The usual process of partnership can come either from the barangays, LGU departments, and private partners. They usually present their proposal to the local council for their approval and endorsement. Once proposal have been endorsed, the agreements between project stakeholders will take place thru MOA or issuance of ordinances or policies. Many proposals came from the private partners, although proposals from LGU departments, like ICT and planning offices were also found to be common.

Capacity building

Aside from partnership, all respondents highlighted the importance of capacity building in implementing smart city projects. Tagum LGU highlighted the importance of capacity building for the departments and not just the leaders, because the political leaders have shorter term compared with the department heads because they can push leaders to proper directions too. This is to ensure that there are specific group of people that will operate and maintain these 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 Tagum LGU*

Capacity building for the public can also be done thru constant trainings, like the initiatives of some cities to support their SMEs. Other LGUs shared their initiative called TED – Technology Ecosystem Development Plan and BIRDC, in partnership with local universities to attract investors. Tuguegarao LGU shared that they also do digital literacy with their ICT office for the benefit of their staff as well as the public.

NGAs also have share experiences of the importance of capacity building. For example, NPC conducts summits and trainings for NGOs, BPOs, LGUs, Tech Orgs about the Data Privacy Act. They also partner with DAP to develop training courses for this. DOST-PCIEERD has SPARTA, which are human resource development courses with DAP. They also have GODDESS initiative to provide fund for capstone projects from SPARTA. The main objective is to encourage students, universities, public servants, and researchers to collaboration and create solutions for public issues locally.

Implementing pilot projects

Respondents shared that engaging in pilot projects were also seen as good pathway for smart city projects in the country. For LGUs, this pathway enables them to access technology or system for free. Cauayan City LGU shared that the city is offered as a city lab to partners, inviting the private and public sector to test their innovations in Cauayan.

Partners on the other hand, use this pathway to further enhance their product or technology. Some implement pilot projects on development of green cities and gather more experience insights from there. Others use the feedback from the LGU and the public to further enhance their product. Their pilot projects with their partner LGUs serve as proof of concept where they can use to market their technology. NGAs usually start supporting projects when they have proof that it works. They can provide support by connecting them to possible funding agencies and technical support. Supporting start-ups and creation of sandbox are also seen as effective way to initiate smart city projects.

Development of customized systems

Majority of the LGUs interviewed mentioned that their initiatives were borne out of specific issues that their city is facing. Often, these initiatives were brought about by partnerships. These initiatives can be supply-driven, wherein technology innovators and producers can propose their products or solutions to LGUs and NGAs for partnership or demand-driven wherein LGUs can specifically seek assistance and support from NGAs and private partners thru formal channels.

Establish Smart City Regional Hub or Innovation Hubs

At least four LGUs mentioned establishment of regional hubs as effective pathway for smart city initiatives. According to them, this is one of the effective strategies to learn from the best practices of their neighboring LGUs in terms of smart city initiatives not to mention avoiding duplication of efforts. One good example is the partnership between Cauayan and Tuguegarao in terms of the development of digital twins for both cities. LGUs and partners value the importance of establishing innovation hubs wherein they can develop people and technology thru partnership in universities, hence creating jobs and sustaining the SC initiatives. Development organizations and NGAs sees this strategy to promote regional development, which will provide frameworks to scale-up initiatives to other cities nationwide. These innovation hubs can also provide avenue wherein development of start-ups is encouraged through technical and funding support.

Incentive Codes and Awards Schemes

One of the strategies to encourage engagement to smart city initiatives is to incentivize these projects. Five LGUs mentioned this as one way to entice engagement from private partners within their cities. Tuguegarao LGU shared that they recently amended their incentives code to attract ICT investments in their city. NGAs like NPC, DILG, and DOST-PCIEERD also see potential in this strategy to encourage partnership between LGUs and the private sector. One

business partner also sees awards and recognition to attract LGUs to partner with the business sector and engage smart initiatives.

Other pathways mentioned by the respondents were development of context-specific applications and systems to address immediate public issues; compliance to required certifications and policies related to permits and licensing, application for funding thru grants or loans here and abroad.

7.2.6. Recommendations

Participants were also asked about the strategies they would recommend addressing the challenges that they encountered in implementing smart city initiatives. Annex 19 describes the different recommendations from the interviews.

LGU-level recommendations

Information dissemination and feedback

One of the key recommendations that the participants shared was the role of public engagement in implementation of smart city projects. LGUs understand that they need the public grasp the reason why they must comply with new policies or use certain applications. Some LGUs shared there were some resistances during their ISO certification or when they have new system or technology to be used. But after they understand and appreciate the reason behind those initiative, their uptake will be faster.

Information are being shared to the public thru various forms like public meetings, use of LED bulletin boards, hotlines, publication material, and social media platforms. Aside from official emails and hotlines, social media platforms played an important role in hearing the feedback from the public due to its accessibility. Many LGUs collect feedback from the public thru their official websites, social media pages and even emails to improve their service delivery. As for the digital divide, LGUs constantly seek ways to address this by providing equipment and providing reliable and accessible Internet connections.

Private partners observed that good public engagement facilitates the smooth implementation of smart city initiatives, especially in projects that involves infrastructure and public participation. One partner shared that it was helpful that the LGU led the information drive involving its project.

Partnership thru formal agreements and ordinances

Many respondents shared the importance of establishing strong partnership between the private partners, national agencies and even the academe. In fact, many LGUs and private partners mentioned that the role of local universities play an important role in developing the people required to operate and sustain smart city projects. Aside from that, one LGU shared the importance of volunteer organizations in ensuring prompt response especially in times of accidents, fire, and disaster. Moreover, these local partnerships will provide context-specific solutions to public concerns. International partnership also plays an important role in the development of smart cities in the country, and these can be facilitated by different NGAs and private partners.

Since partnerships play an important role in implementing smart city initiatives, it is imperative that these relationships are 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 in sustained in the future. One of the participants even shared that ordinance is considered as permanent in nature compared to executive orders which are only effective during the incumbent leader's term.

On some private partners' perspective, MOAs and other forms of agreements ensures the commitment of LGUs in the projects including the role that they will take including the funds that they will allocate for the project.

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 of them opt to institutionalize their ICT and Planning Department. Aside from that, they 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 at the implementing agency.

Develop Smart City Champions
Aside from technical capacity building, the smart city concept should also be enbibed among the LGUs. Many private partners highlighted the importance of smart city champions at the LGU level since it will open opportunities in engaging with them. One business partner reiterated that *"(t)here should be a mutual intent to do a smart city project"* or the initiative will not prosper. Another business partner interviewed mentioned the more they understand the importance of green buildings, LGUs are more likely encouraged to act and engage partnership with them.

Consolidate systems or projects
LGUs are starting to look for ways to integrate these systems and avoid duplication of existing initiatives. This will help them make use of their available resources and information that allow them for informed decision making and policy making. One of the LGUs, for instance, has a plan to make data accessible in one center for informed decision-making. The Malabon City LGU, on the other hand, focuses on having a centralized database for their social and health services by initializing a Malabon ID system.

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

<u>National-level solutions</u>
Creation of a national roadmap or agenda
NGAs and private partners also see the importance of the crafting regional roadmap or hub and national policies and guidelines that will serve as framework that will 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 project duplication. A national guideline will also standardize data collection including application programming interfaces and create a standard index where development of cities can be assessed at the national level. Moreover,

national guidelines crafted using the best practices in the country will allow other cities to learn from the successful smart cities.

Improve monitoring and evaluation
Across different stakeholders, they identified the need to establish a better monitoring and evaluation of smart city initiatives. This is essential especially in the devolution of some of the service due to Mandanas Ruling. PPP Center and DOST-PCIEERD highlighted the importance of having standards. In fact, DOST-PCIEERD highlighted that this contributes to long-term vision for smart cities in the country through integration of data.

> *"…(T)he long-term vision is also for these smart city solutions and data to also, you know, be integrated together for the higher governance levels to also partake on through systems of integration and transmission of the data. So, that's our prospect along with the indexing system. That's why indexing is important."* – Interview with DOST-PCIEERD

This is on top of the existing monitoring system of DILG on the Seal of Good Governance, which is focused only on making sure that service delivery is efficient.

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

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; staggard implementation of big projects especially those involving infrastructure developments; and creation of wireless Internet connection nationwide.

8. Conclusion

The Philippines has started to tread the path towards 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 with LGUs initially thought to be with low level of implementation, have shown the motivation of both the public and private sector to implement smart city initiatives. To take the discussion up a notch, LGUs have been implementing smart city initiatives already. Aspiring smart cities, however, should tread the path carefully because with missteps, the implementation of smart city initiatives can prove to be futile.

8.1. What drives Philippine LGUs towards the implementation of smart city initiatives?

In addressing the first policy question, motivations and enablers to smart city development were identified based on insights on the cases of the interviewed LGUs. LGUs were generally found to be motivated by the expected outcomes of smart city initiatives, while enablers to smart city development already exist in the country.

Despite the issuance of the Philippine National Standards and the DOST-PCIEERD's framework, some stakeholders have not used them as references in implementing their smart city initiatives. Some of the interviewees have not been branding relevant initiatives as smart, while some have chosen to use other terms to brand their activities. When prompted for their definition of the term "smart city", a variety of keywords were relayed.

The outcomes based on reviewed literature, nevertheless, appear to be the motivations of stakeholders of smart city initiatives. The motivations of LGUs were consistent with the three outcomes captured in the working definition, *i.e.*, high quality of life, competitive economy, and sustainable environment. There is also an emphasis on LGUs' desire to address the needs of people and ongoing urban challenges such as public safety, transportation, and those brought about by the COVID-19 Pandemic and disasters. Meanwhile, motivations of NGAs in supporting smart city development are in line with their mandates. Additionally, the private sector expects gains from smart city development, regardless of the nature of their support. The alignment of motivations reflects the potential of aspiring smart cities to become successful.

Enablers for smart city development are already in place based on the interviews, but the degree in which they are applied is not very extensive compared to cases in reviewed literature. Smart city champions, ICT department/personnel, and ICT infrastructure are already present in some of the interviewed LGUs. Such champions promote the vision in carrying out smart city initiatives and reflect the willingness to adopt such initiatives, a factor considered by some partners in proceeding with project implementation. Stakeholder engagement is also an enabler in interviewed LGUs as in the reviewed literature and cases of international cities. Collaborating with the academe has facilitated development in the initiatives. In terms of financial sources, however, while cases of international cities and reviewed literature reflect high importance on PPP-enabled financing, interviewed LGUs have highlighted financial support coming from international organizations, NGAs, and/or local funding agencies more. Based on online resources and documents from the LGUs, financing from internal budget is also a frequent mode used. There are also some biddings carried out.

8.2. 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 being supported by programs and activities of NGAs. For interviewed LGUs, there are generally more initiatives in the Infrastructure Phase, including those involving Internet connectivity, even with cities at high level of implementation. Generally, cities at high level of implementation are focusing more on Built Infrastructure, while those at low level of implementation are concentrating on the Civic and Social domain. The main targets of efforts across all interviewed LGUs are to provide high quality of life to their constituents. There are also generally more initiatives involving institutions, and data and information, while people and knowledge fall short in their respective categories of stakeholders and semiotics, respectively. Generally, LGUs with high level of implementation are with more partners, and those with initiatives dating back longer have more implemented initiatives.

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

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

Challenges have been encountered by interviewees in relation to smart city development. Despite being a source of motivation for the implementation of smart city initiatives, the COVID-19 pandemic also comes with negative implications on finances. Some of the LGUs have chosen not to pursue their smart city projects because of limited budget. Meanwhile, similar to reviewed literature, private sector finds changes in administration or political uncertainty as an obstacle in partnership and sustainability of smart city initiatives. A concern has also been raised on LGUs' being overprotective of their data. There is also a challenge involving public uptake. Additionally, lack of interoperability has been cited as one of the issues with variety of systems even within a single LGU.

Risks and disadvantages being associated with smart city development have only been relayed by a few interviewees, but these are critical areas of concern. Issues concerning data privacy are expected to be tackled more as smart city development increases given the reliance of such growth on the availability of data. Apart from data privacy and the risk of technology being used for political interests, no other risk and disadvantage were discussed in the interviews. There are some other concerns, nevertheless, being raised in some smart city initiatives in the Philippines. These other concerns are particularly centered on smart city initiatives involving reclamation such as in Dumaguete and Manila. As with other reclamation projects, potential environmental degradation and negative implications on the livelihood of fishermen are some of the areas of concern. There is a lack of studies, however, estimating the net benefits or losses from implementing reclamation projects for smart city development.

NGAs, through their policies and programs, have the capacity to address issues and support smart city development. Support from the NGAs is mostly concentrated in the Infrastructure and Data Phases. PPP Center has apparently been supporting the development of PPP projects involving some smart city initiatives. DICT facilitates connectivity. DOST-PCIEERD helps in capacity building for the development of technologies. NPC promotes and monitors data privacy. In terms of the Service Phase, DILG and DICT are supporting the enforcement 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.

The government has taken pathways for smart city development. Information dissemination is being conducted to increase awareness on the relevant projects, while feedback mechanisms are made available. Helping ensure sustainability of smart city initiatives and partnerships are issuances of ordinances, resolutions, and MOAs. Pilot projects are being carried out with gains both in the public and private sector. There are also regional and innovation hubs being developed. Capacity building on digital literacy within departments and the public is also being conducted. Capacity building is also carried out to increase human capital that would support smart city development. While government efforts are notable, additional pathways discussed in the following section can be taken to further support the building of smart cities.

9. Recommendations

Increasing the readiness of Philippine cities to smart city development involves national and local government offices. Presence of enablers and already existing smart city initiatives have signified preparedness to such a development; however, there are unaddressed gaps in the smart city agenda in the Philippines at the national and local levels. If the gaps are unaddressed, there will be a risk of not fully realizing the potential of smart city initiatives.

The Philippines should consider branding its cities as smart. Currently, the terms being associated with similar initiatives aside from “smart city” include “digital city” and “intelligent city”. The rising number of articles on smart city should be one of the grounds in deciding whether to shift the term being used provided that the involved initiatives truly can be categorized as smart. Establishing a brand for Philippine cities can unlock opportunities to gain additional investments for government projects.

Should the Philippines decide to pursue branding applicable initiatives as smart, special roles can be given to the DOST-PCIEERD and DILG to ensure the establishment of a good brand. The DOST-PCIEERD may take the lead in the initial steps, enhancing the DOST Framework for Smart Sustainable Communities and Cities. Meanwhile, the DILG can promote and monitor adoption of the framework and gauge smart city development among Philippine cities based on smart city indicators under PNS ISO 37122:2020. Furthermore, it can implement an accreditation system in accordance with the PNS to incentivize cities to adopt the smart city concept. The DILG can then be equipped with data and evidence when showcasing Philippine cities in international fora, again paving a way for increased investments.

The identified enablers can serve as indicators of readiness to smart city development. While PNS ISO 37122:2020 already provides smart city indicators, measures reflecting the readiness of cities to smart city development will provide insights on the capacity of LGUs to implement smart city initiatives. Based on the discussed enablers, indicators of the readiness to smart city development can include the following: (1) presence of smart city champions; (2) presence of ICT department or personnel; (3) number of completed projects supported by ordinances, resolutions, and/or MOAs involving businesses, development organizations, academic institutions, and/or NGAs; (4) number of constituents with access to Internet connection; and (5) availability of digitized data. These suggested indicators are expected to help LGUs in preparing for smart city development.

Accountability is one of the themes that can enhance the DOST Framework for Smart Sustainable Communities and Cities. The agenda in smart city development 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. The DILG can mandate LGUs to provide data involving their projects on a platform easily accessible by their constituents.

Guidelines on the development of data repositories and standards on application programming interfaces for aspiring smart cities can be issued by DICT and NPC. Aspiring smart cities are not required to be equipped with only one technology addressing all urban challenges to meet their objectives just to ensure interoperability. But they do need to have technologies that are able to transfer data into common but secure data repositories to enable faster evidence-based decision-making.

Risk mitigation strategies should be laid out in the framework on smart cities. Assurance on the non-dismissal of potential negative impacts of smart city projects on environment and livelihood should be given. Especially for PPP projects, the PPP Center can provide guidance in the conduct of feasibility studies and cost-benefit analyses. Meanwhile, given the emphasis of the DOST Framework for Smart Sustainable Communities and Cities on the importance of data and evidence in smart city, ways of ensuring data protection should be discussed. Given NPC's mandate and expertise, the agency can provide guidance on ensuring data privacy in smart city projects including those involving private sector partners. The presence of a comprehensive approach on data protection and its proper implementation in smart cities will encourage constituents to take on their roles in willingly providing data to the government and its partners. Furthermore, similar to some international city governments, LGUs in the Philippines should be transparent on how data are handled for various involved activities.

Smart cities are not meant to stand alone. They are built and maintained by numerous stakeholders. The constituents should have venues where they can raise concerns, ideas, and feedback. Their needs are after all at the core of what smart cities should address. Additionally, support of development organizations in terms of capacitating the LGU should be sought after. LGUs can work with the DOST-PCIEERD in conducting a gap assessment of technologies and needs. The academe should be involved in addressing the gap. Available technologies offered by the private sector should also be assessed on their potential contribution to smart city development, as well as relevant costs. In terms of financing, LGUs can work on expanding the range of options for financing. The conduct of PPP smart city projects should be explored more as an additional option given the emphasis that has been 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 carry out feasibility studies. Engagements with stakeholders should be supported by Ordinances, Resolutions, and MOAs for 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, they should be careful in selecting their initial steps, ensuring the existence of the foundations and enablers of smart cities, while the national government should provide guidance and support in their actions.

10. Annexes

Annex 1. Cauayan City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
E-tricycles and Charging in Minutes station	• E-tricycles; 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	• High Quality of Life
WiFi routers	• WiFi 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
Cellsites and cellular network system	• Installation of cellsites and/or expansion of cellular network system • 4G / LTE	• Infrastructure	• Process • Communicate	• Built Infrastructure	• Data • Information	• People • Institutions	• High Quality of Life
WiFi	• Obtainment of WiFi services	• Infrastructure	• Process • Communicate	• Built Infrastructure	• Data • Information	• People • Institutions	• High Quality of Life

Barangay Centralized WiFi 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 • Insitutions	• High Quality of Life
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 • Providing 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	• Safety and Security	• Data • Information • Knowledge	• People • Institutions	• High Quality of Life • Sustainable Environment

			• Communicate				
Waste-to-energy plant	• Generate energy using waste products from Cagayan Valley	• Infrastructure	• Process • Translate	• Quality Environment	• Data • Information	• Institutions	• Sustainable Environment
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
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

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 2. Cauayan City initiatives' administrative details

Initiative	Partner*	Finance	Timeline	Output	Ordinance / Resolution / Memorandum
E-tricycles and Charging in Minutes station	• DOST • Isabela State University • University of the Philippines Diliman • DOST-PCIEERD • Electronics Industries Association of the Philippines, Inc.	• Commercial viability supported through financial aid from DOST	• 2017: Parade of prototype models	• 2 installed chargers	
Hybrid Electric Road Train	• DOST-Metals Industry Research and Development Center	• From DOST	• 2019: Launch and turnover	• 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		

WiFi routers		• 2014: Distribution to 65 barangays	• 65 barangays equipped with free WiFi routers	
Fiber optics	• PLDT Inc.	• 2017: Installed fiber optics		
Cellsites and cellular network system	• Smart / Smart Communications / Smart Telecommunication / Smart Telecommunications Inc. / Smart Communications Inc.	• 2005 - 2019: Approval of Resolutions on installation of cellsites and/or expansion of cellular network system		• Resolutions No. 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
WiFi	• Smart Communications, Inc.	• 2019: Approval of Resolution		• Resolution No. 2019-6-070
Barangay Centralized WiFi Network			• 65 barangays became equipped with communication network and Internet	
QR Code for Barangay Constituents			• Barangay Cabaruan constituents with QR codes - Population of 8,244	

Cauayan City App	• Multisys Technologies Corporation		• 2014: Launch of 1st version • 2019: Launch of 2nd version	• Total downloads from App Store: - China: 3,179 - Philippines: 832 - US: 89 - Japan 74 - Singapore: 79 • Total downloads from Play Store: - Philippines: 18,224 - Saudi Arabia: 126 - US: 98 - Canada: 66 - Taiwan: 37 - India: 22 - South Korea: 20 - Italy: 18 - Japan: 16 - Brazil: 13
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 JuanTime and Disaster Information distributed
Kiosk machines				
Police drones			• 2019: Barangay Cabauran Police became equipped with drone	• 3 drones deployed for monitoring of constituents during lockdown

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, PHP22 million damages to crops, and PHP550 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	
Investment Website					
Water Quality Testing Laboratory	• DOST • Isabela State University		• 2017: Resolution approved		• Resolution No. 2017-6-122: RESOLUTION AUTHORIZING THE HONORABLE CITY MAYOR BERNARD FAUSTINO M. DY, TO ENTER INTO A MEMORANDUM OF AGREEMENT WITH THE DEPARTMENT OF SCIENCE AND TECHNOLOGY 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				
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		

Source: Authors' summary of initiatives based on documents from interviewees and 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
Free WiFi	• Free WiFi in some public areas through fiber optic wide area network	• Infrastructure	• Process • Communicate	• Civic and social	• Data • Information	• People • Institutions	• High Quality of Life

Tuguegarao Government Portal	• Online government services (Travel Pass Application; Checkpoint Registration; QR Card for Non-Residents; Online Payment and QR for Residents and Non-Residents; 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

Source: Authors' summary of initiatives based on documents from interviewees and 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 and Protection				
Free Direct Internet	• Globe Business	• From Globe Business			
Free WiFi					
Tuguegarao Government Portal					
MyCure System	• DOST				

Source: Authors' summary of initiatives based on documents from interviewees and 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 WiFi in City Hall and Old Public Market	• Fiber-powered WiFi in City Hall and Old Public Market	• Infrastructure	• Process • Communicate	• Built Infrastructure	• Data • Information	• People • Institutions	• High Quality of Life
Free WiFi in public schools	• WiFi 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
Solar panels	• Renewable energy source	• Infrastructure	• Sense • Process	• Quality Environment	• Data • Information	• Institutions	• Sustainable Environment
Online business registration	• Business registration can be done online with option for delivery service	• Service	• Process • Communicate	• Civic and Social	• Data • Information	• People • Institutions	• Competitive Economy
Integrated/centralized systems for inter-office transactions	• Development of applications and integrated/centralized systems to expand linkage of inter-office transactions	• Infrastructure	• Process • Communicate	• Civic and Social	• Data • Information	• Institutions	• High Quality of Life

Source: Authors' summary of initiatives based on documents from interviewees and 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 work stations • Additional 26 video walls	
Free WiFi 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 WiFi in public schools				• 9 Early Childhood Care and Development Centers	
Smart City Phase II Program technologies	• LandBank of the Philippines	• Loan from LandBank of the Philippines • 2021 Annual Investment Program: PHP 100 Million	• 2021: Allotment in Annual Investment Program		
Solar panels					
Online business registration	• 2Go Express Inc.		• 2018: Signing of MOA	• Issuance of 11 new business permits • Renewal of 3 business permits • Issuance of 745 new business/building clearance • Renewal of 4,532 business/building clearance	• MOA with 2Go Express Inc. under Resolution 2018-024

Integrated/centralized systems for inter-office transactions					• 2 systems developed for the linking of some government units • 10% completion of data gathering stage fo in-house development of online application of building clearance		

Source: Authors' summary of initiatives based on documents from interviewees and 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 WiFi	• 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

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 8. Malabon City initiatives' administrative details

Initiative	Partner*	Finance	Timeline	Output	Ordinance / Resolution / Memorandum
CCTV Cameras		• PHP9,985,000.00: Internal budget	• 2017: Bid Opening		
Mobile connectivity	• Globe			• 6 new cell sites • 101 upgraded sites	
Free WiFi	• Smart Communications Inc. • PLDT	• From Smart Communications Inc.			
Contact Tracing App					
Computerization of tax collection data and transactions		• PHP3.8 Million: Internal budget			
Online Payment Services System	• IB Solutions IBS Worldwide Corporation		• 2020: Contract with IB Solutions IBS Worldwide Corporation signed		

Source: Authors' summary of initiatives based on documents from interviewees and 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
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 • Modelling of Urban Heat Islands in Philippine Cities (Project GUHeat) • Urban Gardening • Biodegradable waste shredder • Rotary drum composter	• Infrastructure	• Sense • Monitor • Process • Translate • Communicate	• Quality Environment	• Data • Information • Knowledge	• People • Institutions	• Sustainable Environment

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 10. Mandaue City initiatives' administrative details

Initiative	Partner*	Finance	Timeline	Output	Ordinance / Resolution / Memorandum
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	• ORDN. #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
Guardian Emergency Response System	• Sugbotek Inc.	• Free application provided by Sugbotek Inc.	• 2018: Signing of MOA		• MOA with Sugbotek Inc.
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		

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 - Environment Management Bureau • 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 - Environment Management Bureau • 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 No. 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

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 11. Davao City initiatives' alignment with working definition

Initiative	Description	Phase	Function	Focus Area	Semiotics	Stakeholders	Outcomes
High Priority Bus System	• Bus services made available through a 626-km road network	• Infrastructure	• Process • Translate	• Built Infrastructure	• Data • Information	• Institutions	• High Quality of Life
Underground Distribution System	• Removal of dangling overhead wires	• Infrastructure	• Process • Communicate	• Built Infrastructure	• Data • Information	• People • Institutions	• High Quality of Life
No Contact Apprehension	• Traffic enforcement cameras • Speed gun • CCTV cameras • Digital cameras • QR Code • Dashboard	• Data	• Sense • Process • Communicate	• Built Infrastructure • Safety and Security	• Data • Information	• People • Institutions	• High Quality of Life
Central 911	• System that connects constituents to nearest emergency responders • Emergency Computer-Aided Dispatch • GPS • GIS • Early warning system	• Service	• Sense • Process • Translate • Communicate	• Safety and Security	• Data • Information • Knowledge	• People • Institutions	• High Quality of Life

Safe Davao QR	• Platform for travel pass and contact tracing	• Service	• Sense • Monitor • Process • Communicate	• Health and Well-being	• Data • Information • Knowledge	• People • Institutions	• High Quality of Life
COVID-19 Electronic Immunization Registry	• Platform for masterlisting and registration for COVID-19 vaccination	• Data	• Monitor • Process • Communicate	• Health and Well-being	• Data • Information	• People • Institutions	• High Quality of Life
RT-PCR Machine	• Testing machine for laboratory facility	• Infrastructure	• Sense • Process • Communicate	• Health and Well-being	• Data • Information • Knowledge	• People • Institutions	• High Quality of Life
Internet	• Fiber optics • WiFi in airports	• Infrastructure	• Process • Communicate	• Built Infrastructure	• Data • Information	• People • Institutions	• High Quality of Life
Biodiesel fuel	• Conversion of cooking oil to fuel	• Infrastructure	• Process • Translate	• Quality Environment	• Data • Information	• Institutions	• Sustainable Environment
Online business permit registration and renewal	• Online application for business permit	• Service	• Process • Communicate	• Civic and Social	• Data • Information	• People • Institutions	• High Quality of Life
PUV Drivers' ID with QR Codes	• IDs with QR codes to ease reporting of traffic violations	• Data	• Sense • Process • Communicate	• Civic and Social • Industry and Innovation	• Data • Information	• People • Institutions	• High Quality of Life
Electronic Halal Hub Trade Facilitation Platform	• Platform for Mindanao SME halal products	• Service	• Process • Communicate	• Industry and Innovation	• Data • Information	• Institutions	• Competitive Economy
Davao City Disaster Radio	• Provides information on disaster preparedness and LGU activities	• Infrastructure	• Process • Communicate	• Safety and Security	• Data • Information	• People • Institutions	• High Quality of Life

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 12. Davao City initiatives' administrative details

Initiative	Partner*	Finance	Timeline	Output	Ordinance / Resolution / Memorandum
High Priority Bus System	• DOTr • LTO • LTFRB • ADB • GHD Pty Ltd • DTI	• Transport Roadmap financed by ADB • PHP 18.66 Billion through Official Development Assistance (Social Development Program, Institutional Capacity Strengthening, and Public Transport System Improvement)	• 2019: Approved by NEDA Investment Coordination Committee • 2019: Enacted Ordinance on transfer of funds from DTI to Davao City for social development of HPBS • 2021: Enacted Ordinance for the Livelihood Restoration Program in relation to the High Priority Bus System • 2023 Q3: Targeted to be fully operational		• ORDINANCE NO. 0137-19 SERIES OF 2019: AN ORDINANCE AUTHORIZING THE CITY MAYOR TO ENTER INTO AND SIGN FOR AND IN BEHALF OF THE CITY GOVERNMENT OF DAVAO, THE MEMORANDUM OF AGREEMENT TO BE ENTERED INTO WITH THE DEPARTMENT OF TRADE AND INDUSTRY RELATIVE TO THE TRANSFER OF FUNDS TO THE CITY GOVERNMENT INTENDED FOR THE SOCIAL DEVELOPMENT OF THE HIGH PRIORITY BUS SYSTEM PROJECT OF THIS CITY • ORDINANCE NO. 0606-21, SERIES OF 2021: AN ORDINANCE AUTHORIZING THE CITY MAYOR TO ENTER INTO AND SIGN, FOR AND IN BEHALF OF THE CITY OF DAVAO, THE AMENDED MEMORANDUM OF AGREEMENT (MOA) BEETWEEN THE CITY OF DAVAO AND THE DEPARTMENT OF TRADE AND INDUSTRY (DTI) RELATIVE TO THE LIVELIHOOD RESTORATION PROGRAM FOR THE DISPLACED DRIVERS, OPERATORS, ALLIED WORKERS, AND OTHER SECTORS AFFECTED BY THE IMPLEMENTATION OF THE HIGH PRIORITY BUS SYSTEM (HPBS) PROJECT

Underground Distribution System	• Davao Light and Power Company	• Around PHP1 Billion for 2nd Phase (6 circuit kilometers of overhead lines)	• 2014: Enacted Ordinance on underground cabling • 2017: Enacted Ordinance requiring compliance with underground cabling plan • 2017: Phase 1 completed	• Removal of underground cables along downtown area surrounding LGU buildings	• ORDINANCE NO. 0177-14, SERIES OF 2014: AN ORDINANCE PLACING UNDERGROUND ALL ELECTRICAL AND TELECOMMUNICATION WIRES AND CABLES WITHIN THE VICINITY OF CITY HALL AND THE SANGGUNIANG PANLUNGSOD OF THE CITY OF DAVAO • ORDINANCE NO. 0152-17, Series of 2017: AN ORDINANCE REQUIRING ALL TELECOMMUNICATION COMPANIES, DAVAO LIGHT AND POWER COMPANY (DLPC) AND ALL OTHER PERSONS TO COMPLY WITH THE UNDERGROUND CABLING PLAN OF THE CITY OF DAVAO
No Contact Apprehension	• Qpax Traffic Systems Inc.	• Php 0.0495 Billion for project with Qpax Traffic Systems Inc.		• 190 surveillance cameras	
Central 911	• Davao Light and Power Company • Auspex • Sun Cellular • Smart Communications • Globe Telecom • Bayantel • PLDT		• 1997: Partnership made with Davao Light and Power Company for Davao City Street Lighting Project • 2002: Launch		

Safe Davao QR			• 2020: Enacted Ordinance requiring mandatory implementation of Safe Davao QR • 2021: Amended Ordinance requiring mandatory implementation of Safe Davao QR		• ORDINANCE NO. 0431-20, SERIES OF 2020: AN ORDINANCE REQUIRING THE MANDATORY IMPLEMENTATION OF THE SAFE DAVAO QR (DQR) FOR ALL ESTABLISHMENTS AND ALL INDIVIDUALS, INCLUDING NON-RESIDENTS OF DAVAO CITY • ORDINANCE NO. 0628-21, SERIES OF 2021: AN ORDINANCE REQUIRING THE MANDATORY IMPLEMENTATION OF THE SAFE DAVAO QR (DQR) FOR ALL ESTABLISHMENTS AND ALL INDIVIDUALS, INCLUDING NON-RESIDENTS OF DAVAO CITY, AS AMENDED
COVID-19 Electronic Immunization Registry			• 2021: Importation of data to system		• ORDINANCE NO. 0478-21, SERIES OF 2021: AN ORDINANCE FOR THE IMPLEMENTATION OF THE COVID-19 IMMUNIZATION PROGRAM OF DAVAO CITY
RT-PCR Machine	• DOT	• From DOT	• 2021: Enacted Ordinance to accept Deed of Donation	• 1 unit of RT-PCR Machine	• ORDINANCE NO. 0460-21, SERIES OF 2021: AN ORDINANCE AUTORIZING THE CITY MAYOR TO ACCEPT AND SIGN, FOR AND IN BEHALF OF THE CITY OF DAVAO, THE DEED OF DONATION (DOD) TO BE EXECUTED BY AND BETWEEN THE DEPARTMENT OF TOURISM XI AND THE CITY OF DAVAO PERTAINING TO THE DONATION OF ONE (1) UNIT REVERSE TRANSCRIPTION POLYMERASE CHAIN REACTION (RT-PCR) MACHINE TO THE CITY TO BE USED AS A TESTING MACHINE FOR THE LABORATORY FACILITY IN BARANGAY LOS AMIGOS, TUGBOK DISTRICT, THIS CITY

Internet	• PLDT				
Biodiesel fuel	• Japanese government • JICA • Biomass Japan, Inc. • Shinozaki Transport Warehouse Co., Ltd	• PHP 10 Million financed by JICA	• 2017: Launch	• 1,800 liters of biodiesel fule processed to power vehicles during inauguration	
Online business permit registration and renewal				• Website	
PUV Drivers' ID with QR Codes			• 2018: Start of apprehension of drivers without ID	• 19,000 PUV ID cards released	
Electronic Halal Hub Trade Facilitation Platform	• Fusionex		• 2021: Enacted Ordinance to enter into NDA for the collaboration		• ORDINANCE NO. 0520-21, SERIES OF 2021: AN ORDINANCE GRANTING LEGISLATIVE AUTHORITY TO THE CITY MAYOR TO ENTER INTO AND SIGN, FOR AND IN BEHALF OF THE CITY OF DAVAO, THE CONFIDENTIALITY AGREEMENT/NON-DISCLOSURE AGREEMENT BETWEEN THE CITY GOVERNMENT OF DAVAO AND FUSIONEX, TO FACILITATE COOPERATION AND COLLABORATION PARTICULARLY IN THE AREA OF ELECTRONIC HALAL HUB TRADE FACILITATION PLATFORM IN DAVAO CITY
Davao City Disaster Radio	• Governors of Region XI provinces • AFP		• 2020: Started to air		• Manifesto with governors • MOA with AFP

Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 13. 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

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
Smart street lighting	• Solar-powered street lights 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	• Computers • Internet service	• Infrastructure	• Process • Communicate	• Industry and Innovation	• Data • Information	• People • Institutions	• Competitive Economy

Source: Authors' summary of initiatives based on documents from interviewees and online resources

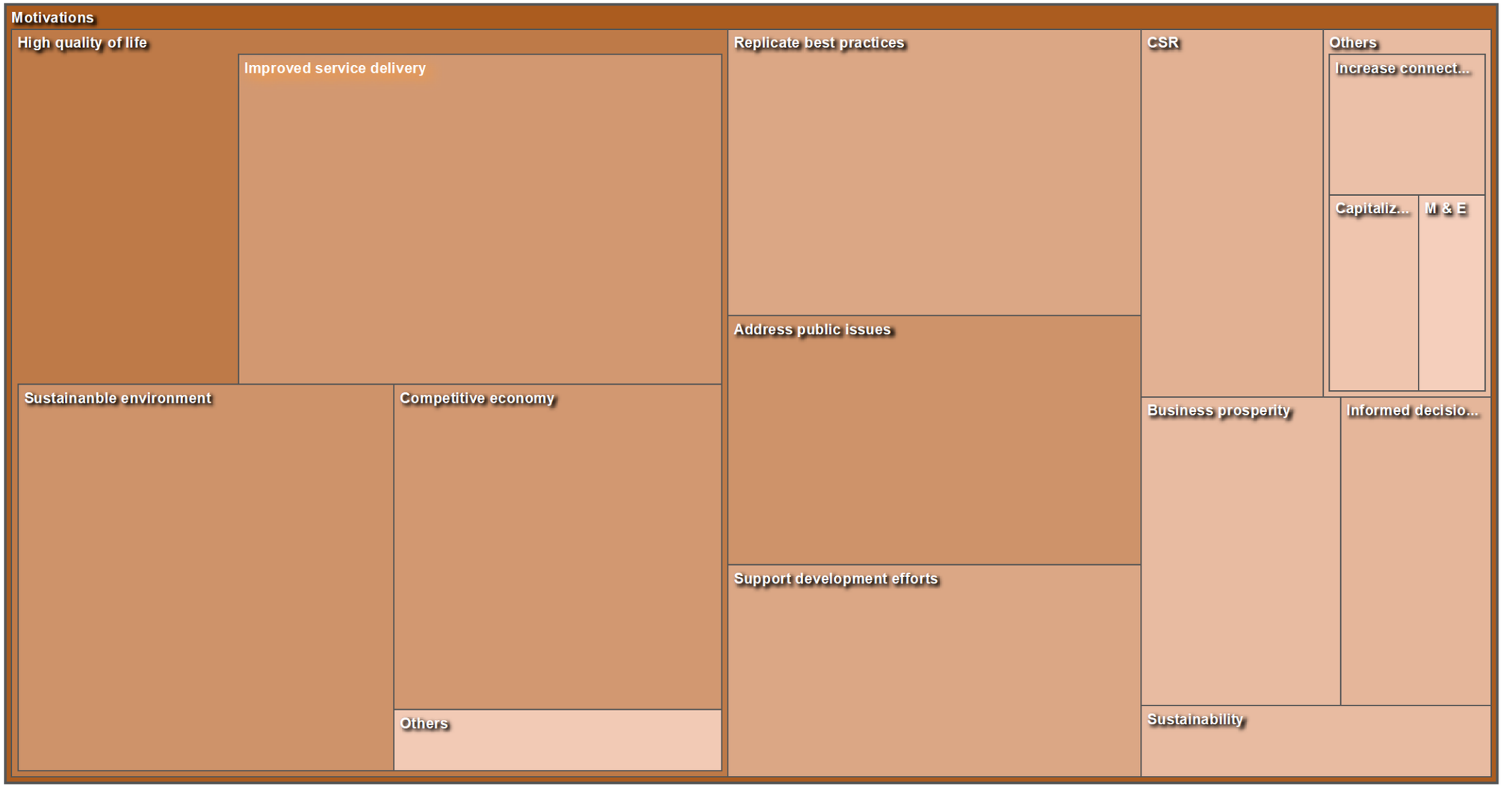
Annex 14. Tagum City initiatives' administrative details

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 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 & 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
Smart street lighting		• 1st Phase (13 units): Php 60,000.00 • For 2022, the Electrification Program has proposed amount of PHP 226,040,000.00 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 pre-construction	
e-Center	• DICT		• 2018: Launch	

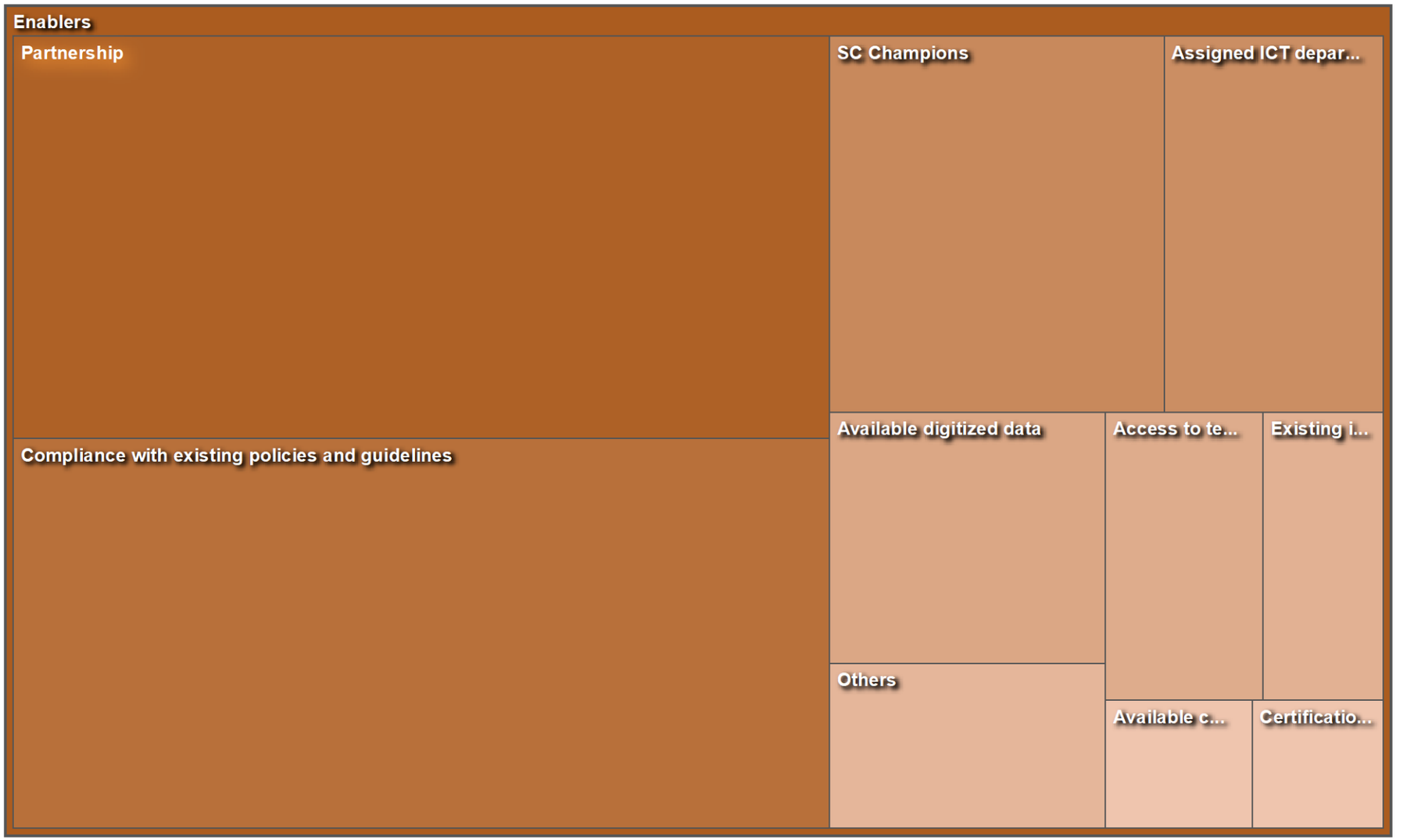
Source: Authors' summary of initiatives based on documents from interviewees and online resources

Annex 15. Summary of themes for motivations for smart city engagements



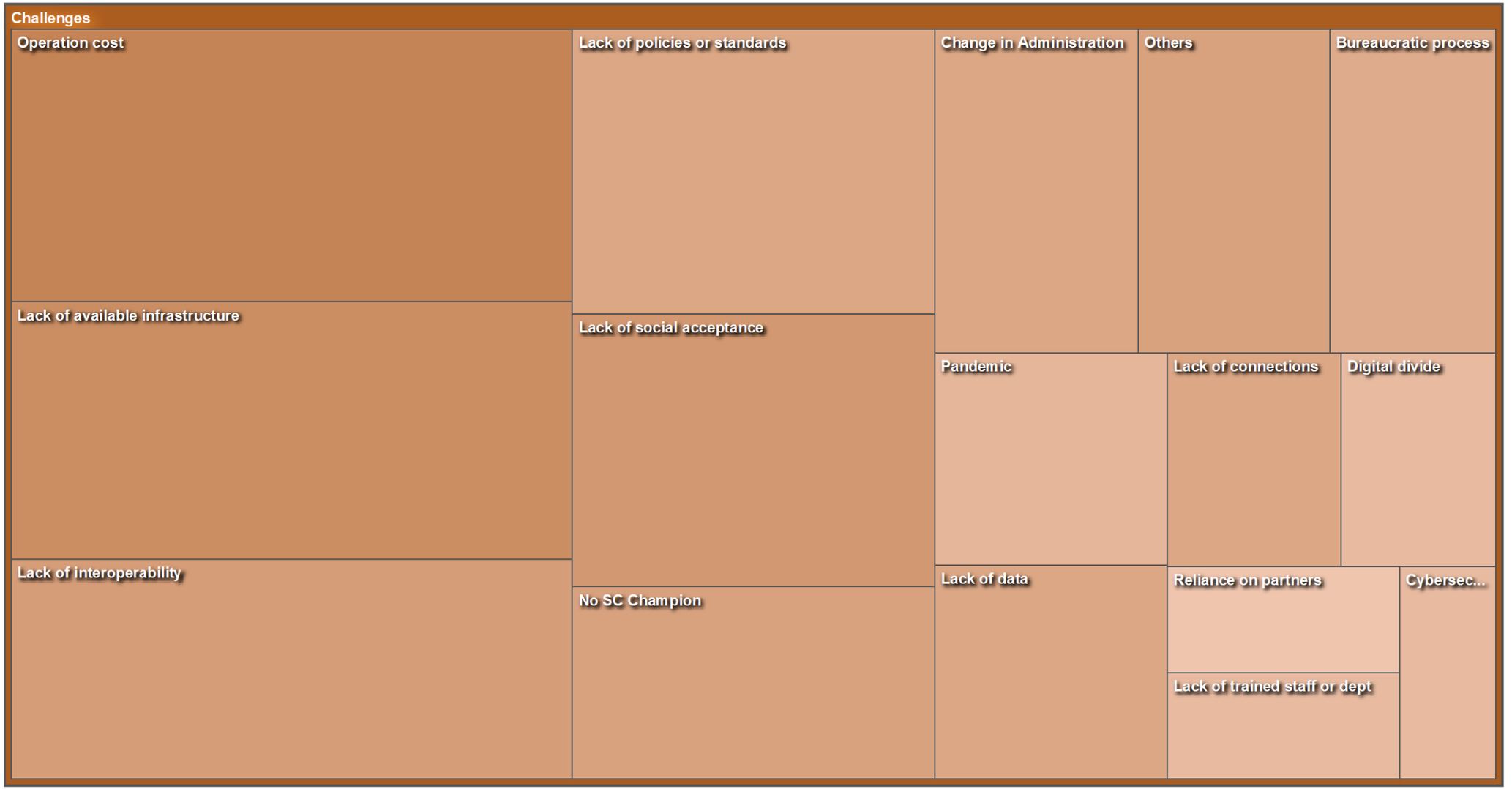
Source: Authors

Annex 16. Summary of themes for enablers based on interview responses



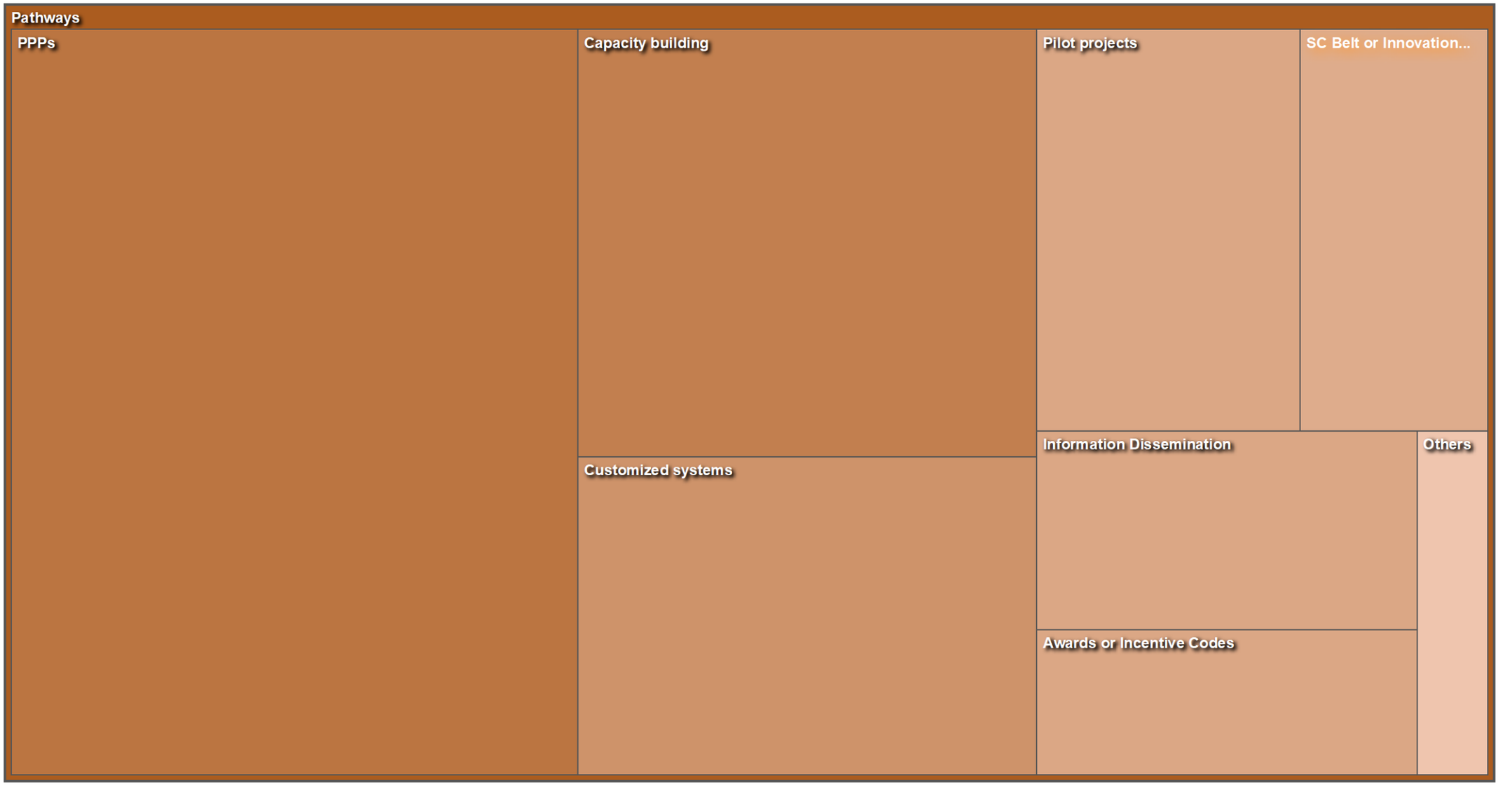
Source: Authors

Annex 17. Summary of themes for challenges from interviews



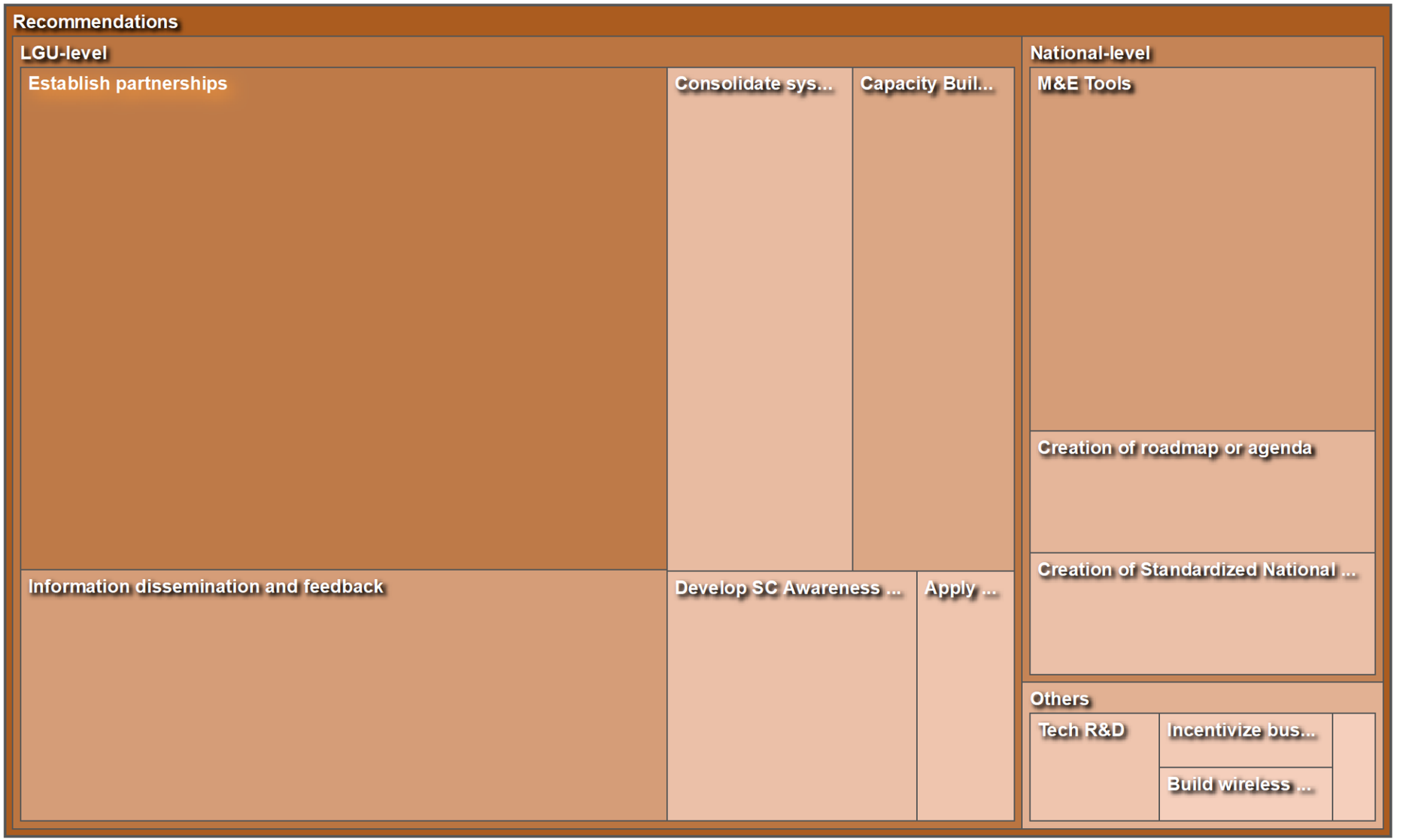
Source: Authors

Annex 18. Summary of pathways for smart city initiatives from interviews



Source: Authors

Annex 19. Summary of themes for recommendations based on interview responses



Source: Authors

11. References

Abad, R. 2019. Smart lighting system to transform Puerto Princesa. Business Mirror. https://businessmirror.com.ph/2019/03/27/smart-lighting-system-to-transform-puerto-princesa/ (accessed November 23, 2020).

ABB. 2019. ABB upgrades landmark buildings in Zaragoza's smart city project with energy monitoring system. https://new.abb.com/news/detail/16297/abb-upgrades-landmark-buildings-in-zaragozas-smart-city-project-with-energy-monitoring-system (accessed on November 10, 2021).

Aglipay, M. 2020. KonekTayo WiFi hotspots now available in Pasig. UNBOX PH. https://unbox.ph/editorials/ph-digital-and-tech/konektayo-wifi-hotspots-now-available-in-pasig/ (accessed on June 5, 2021).

Agoot, L. 2021. Smart City Command Center to improve services in Baguio. Philippine News Agency. https://www.pna.gov.ph/articles/1153128 (accessed on November 23, 2021).

Alama, R.I. 2019. Sustainable green city to rise in Tagum. Philippine Information Agency. https://pia.gov.ph/news/articles/1027385 (accessed on June 9, 2021).

Albino, V., U. Berardi, and R.M. Dangelico. 2015. Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology* 22(1):3-21. DOI: 10.1080/10630732.2014.942092. https://edisciplinas.usp.br/pluginfile.php/4873812/mod_resource/content/1/Leit%2001%20-%20ALBINO%2C%20BERARDI%2C%20DANGELICO%20%282015%29%20Smart%20Cities%20Definitions%20Dimensions%20Performance%20and%20Initiatives.pdf (accessed on May 11, 2021).

ALMEC Corporation; Ernst & Young Advisory Co., Ltd.; and Michi Creative City Designers Inc. 2017. Asia-Pacific Economic Cooperation Secretariat. https://www.iri.edu.ar/wp-content/uploads/2017/07/apec-INCORPORAR.pdf (accessed on June 8, 2021).

Almirol, A. 2017. E-trikes, 'CHARM' launched in Isabela. Manilastandard.net. https://manilastandard.net/mobile/article/237351 (accessed on October 20, 2021).

Amadora, L. 2020. Baguio City and its Vision of A Smart City. Manila Bulletin. https://mb.com.ph/2020/10/28/baguio-city-and-its-vision-of-a-smart-city/ (accessed on November 23, 2021).

Amojelar, D.G. 2019. Globe provides internet services to Tuguegarao. Manilastandard.net. https://www.manilastandard.net/business/it-telecom/285384/globe-provides-internet-services-to-tuguegarao.html (accessed on October 21, 2021).

Arcellaz, P.C. 2020. CSF inaugurates P220M command, control center. Sunstar Pampanga. https://www.sunstar.com.ph/article/1877176/Pampanga/Local-News/City-of-San-Fernando-inaugurates-P220M-command-control-center (accessed on October 21, 2021).

Arevalo, R. and J. Santos. 2019. Marikina to become pilot city of 'Safe PH Project' in Metro Manila. Manila Bulletin. https://mb.com.ph/2019/10/20/marikina-to-become-pilot-city-of-safe-ph-project-in-metro-manila/ (accessed on June 16, 2021).

ASEAN (2018). *ASEAN Smart Cities Network: Smart City Action Plans*. https://asean.org/storage/2019/02/ASCN-Consolidated-SCAPs.pdf (accessed on April 30, 2021).

Asia-Pacific Economic Cooperation (APEC). 2021. APEC Case Study: Best Practice of Smart Cities in the Digital Age. Singapore: APEC.

AVEVA. 2020. Valdespartera becomes Spain's first sustainable "smart city" with a little help from AVEVA. https://www.aveva.com/content/dam/aveva/documents/perspectives/success-stories/SuccessStory_AVEVA_EcocityValdesparteraZaragoza_03-20.pdf.coredownload.inline.pdf (accessed on November 10, 2021).

Ayuntamiento de Zaragoza. 2021. Registro de actividades de tratamiento. https://www.zaragoza.es/sede/portal/registro-actividades-tratamiento#Nombre-fichero-PROTECCI%C3%93N-DE-DATOS-DE-CAR%C3%81CTER-PERSONAL (accessed on November 10, 2021).

Baker, J., M. Watanabe, B. Varona Soriano, L. Limkin, T. Shi, C. Hooton, M. Piatkowski, D. Sivaev, F. Adji, J. Toborowicz, L. Tang, J. Nebrija, F. Eleazar, and M. Martinez. 2017. Philippines urbanization review: Fostering competitive, sustainable and inclusive citiesL Full report. World Bank Group. https://documents1.worldbank.org/curated/en/963061495807736752/pdf/114088-REVISED-PUBLIC-Philippines-Urbanization-Review-Full-Report.pdf (accessed on November 10, 2021)

Balinbin, A.L. 2021. 8 cities, 1 town launch 5-year digital roadmaps; 100,000 jobs targeted.
Business World Online. https://www.bworldonline.com/8-cities-1-town-launch-5-year-digital-roadmaps-100000-jobs-targeted/ (accessed on November 24, 2021).

Barrientos, M. 2021. Las Piñas city now benefits from free smart WiFi. GIZGUIDE. https://www.gizguide.com/2021/03/free-smart-wifi-las-pinas.html (accessed on June 7, 2021).

Bhattacharya, A. 2018. My urban challenge: Smart city officer of Cebu. https://govinsider.asia/digital-gov/my-urban-challenge-cebu-smart-city-officer-paul-villarete/ (accessed on June 8, 2021).

Brgy. Cabaruan. 2020. Patrol drone. https://www.cabaruan-cauayancity.com/index.php/blog/post/XPY~ (accessed on October 18, 2021).

Burgos, N.P. 2020, December 15. DICT names Iloilo tracing app best pandemic response initiative.
INQUIRER.NET. https://newsinfo.inquirer.net/1371692/dict-names-iloilo-tracing-app-best-pandemic-response-initiative (accessed on November 23, 2021).

Bureau of Philippine Standards. 2020. PNS ISO 37122:2020 (ISO published 2019): Sustainable cities and communities – Indicators for smart cities. International Organization for Standardization.

Burgos, S. 2019. LGU bent on being 'smart city'. Mindanao Times. https://mindanaotimes.com.ph/2019/11/29/lgu-bent-on-being-smart-city/ (accessed on June 8, 2021).

Busan Metropolitan City. n.d.-a. Guidelines for handling personal information. https://www.busan.go.kr/eng/privacy (accessed on November 10, 2021).

Busan Metropolitan City. n.d.-b. Busan Eco Delta Smart City. https://www.busan.go.kr/eng/ecodelta01 (accessed on November 9, 2021).

BusinessWorld. 2021. Paranaque City taps MultiSys to deliver more online services for
Paranaque residents, businesses. *Business World Online*. https://www.bworldonline.com/paranaque-city-taps-multisys-to-deliver-more-online-services-for-paranaque-residents-businesses/ (accessed on November 22, 2021).

BusinessWorld. 2018. 1st free TECH4ED station opens in Tagum City. https://www.bworldonline.com/1st-free-tech4ed-station-opens-in-tagum-city/ (accessed on December 1, 2021).

Cable News Network Philippines (CNN PH). 2021, June 14. LIST: Where to register for your free COVID-19 shot. *CNN Philippines*. https://cnnphilippines.com/news/2021/3/29/LIST-COVID-19-vaccine-registration-LGUs.html (accessed on November 22, 2021).

Cabuenas, J.V.D. 2019. PLDT gearing up to 'fully fiberize' Cauayan, Isabela. GMA News. https://www.gmanetwork.com/news/money/companies/711818/pldt-gearing-up-to-fully-fiberize-cauayan-isabela/story/ (accessed on October 20, 2021).

Caliwan, C.L. 2020. Taguig launches first-ever disaster visibility information system. Philippine News Agency. https://www.pna.gov.ph/articles/1093202 (accessed on June 8, 2021).

Camus, M.R. 2021. PPP Center says projects cleared for its PDMF program. Philippine Daily Inquirer. https://business.inquirer.net/315074/ppp-center-says-projects-cleared-for-its-pdmf-program (accessed on November 27, 2021).

Canedo, K.V. 2018. Davao City's PUV drivers' ID to have QR code. SunStar Philippines. https://www.sunstar.com.ph/article/423653/Business/Davao-Citys-PUV-drivers-ID-to-have-QR-code (accessed on November 7, 2021).

Cantalejo, L.R. 2013. LGUs, agencies want centralized response. SunStar Philippines. https://www.sunstar.com.ph/article/274538/Business/LGUs-agencies-want-centralized-response (accessed on December 1, 2021).

Carbungco, M.J.S. 2020. Angeles City beefs up effort on e-governance. Philippine Information Agency. https://pia.gov.ph/news/articles/1056583 (accessed on June 9, 2021).

Carillo, C.C. 2017. JICA-funded P10-M biodiesel fuel plant in Davao is PHL's first. BusinessWorld. https://www.bworldonline.com/jica-funded-p10-m-biodiesel-fuel-plant-davao-phls-first/ (accessed on October 21, 2021).

Cauayan City Economic and Investment Promotion Website. 2019. Cauayan City: Investment Website. https://ceipo.cityofcauayan.gov.ph/ (accessed on October 19, 2021).

CDODev Admin. 2018, January 12. CDO Traffic Light System Project with CCTV to be completed by mid-February 2018. CDODev.Com. http://www.cdodev.com/2018/01/12/cdo-traffic-light-system-project-with-cctv-to-be-completed-by-mid-february-2018/ (accessed November 23, 2021).

Cepeda, M. 2020. In numbers; Abby Binay's tech-driven thrust for Makati in 2019. Rappler. https://www.rappler.com/newsbreak/iq/numbers-abby-binay-state-city-address-makati-january-2020 (accessed on June 7, 2021).

Chavez, C. 2021. PH to finish six Cebu, Manila, Davao smart city projects – DILG. Manila Bulletin. https://mb.com.ph/2021/09/01/ph-to-finish-six-cebu-manila-davao-smart-city-projects-dilg/ (accessed on November 22, 2021).

City of Angeles. 2020. About. City of Angeles. City of Angeles. https://www.cityofangeles.ph/about (accessed on June 9, 2021).

City of Manila. 2020. *About*. https://www.cityofmanila.ph/about (accessed on June 4, 2021).

City of San Juan Local Government System. 2020. *Frequently asked questions (FAQs)*. https://www.cityofsanjuan.ph/faq (accessed on June 7, 2021).

City of Zamboanga. 2021, June 2. ZC adopts StaySafe QR code system. City of Zamboanga. https://zamboangacity.gov.ph/zc-adopts-staysafe-qr-code-system/ (accessed on November 23, 2021).

Coastal Cities at Risk in the Philippines. 2019. CCARPH signs partnership agreement with the Pasig City government. Coastal Cities at Risk in the Philippines. https://coastalcitiesatriskph.com/2019/09/06/ateneo-de-manila-signs-partnership-agreement-with-the-pasig-city-government/ (accessed on June 5, 2021).

Dagooc, E.M. 2018. Cebu City wins big in Digital Cities awards. *The Philippine Star*. https://www.philstar.com/the-freeman/cebu-business/2018/10/20/1861628/cebu-city-wins-big-digital-cities-awards (accessed on November 22, 2021).

Daroya, B. B. 2021, June 2021. NEDA-CAR visits Baguio's Smart City Command Center. NEDA-CAR. https://car.neda.gov.ph/neda-car-visits-baguios-smart-city-command-center/ (accessed on November 23, 2021).

Davao City Government. 2020. Davao City 'Disaster Radio' goes on air. https://www.davaocity.gov.ph/disaster-risk-reduction-mitigation/davao-city-disaster-radio-goes-on-air/ (accessed on November 6, 2021).

Davao City Government. 2018a. Davao City Central 911 Emergency Response Center. https://www.davaocity.gov.ph/departments/social-services/central-911/ (accessed on September 28, 2021).

Davao City Government. 2018b. Processing of business permits. https://www.davaocity.gov.ph/services/social-services/processing-of-business-permits/ (accessed on October 21, 2021).

Davao City Government. n.d.-a. Davao City Transport Roadmap: Summary Report. https://www.davaocity.gov.ph/wp-content/uploads/2019/04/Davao-City-Tranport-Roadmap-Summary-Report.pdf (accessed on September 28, 2021).

Davao City Government. n.d.-b. Frequently asked questions. https://www.safe-davao.com/faq.html (accessed on September 28, 2021).

David, J. 2020a. Navotas presents tracker to CODE. Manila Standard. https://manilastandard.net/mobile/article/333816 (accessed on June 16, 2021).

David, J. 2020b. Malabon pilots contact tracing app via QR code for LGU employees. Manilastandard.net. https://www.manilastandard.net/lgu/ncr/334565/malabon-pilots-contact-tracing-app-via-qr-code-for-lgu-employees.html (accessed on November 23, 2021).

Dela Cruz, R.C. 2021. DOTr eyes completion of Davao High Priority Bus System in 3Q 2023. Philippine News Agency. https://www.pna.gov.ph/articles/1150735 (accessed on September 28, 2021).

Dela Cruz, R.C. 2020. 25 PH cities chosen to be next 'digital cities' by 2025. PNA. https://www.pna.gov.ph/articles/1107517 (accessed on November 15, 2021).

DENR-EMB. 2021. DENR-EMB 7 donates solid waste management technology to Mandaue City. https://r7.emb.gov.ph/denr-emb-7-donates-solid-waste-management-technology-to-mandaue-city/ (accessed on September 27, 2021).

Development Academy of the Philippines. 2020. Central Communications and Emergency Response Center (Central 911). https://coe-psp.dap.edu.ph/compendium-innovation/central-communications-and-emergency-response-center-central-911-2/ (accessed on December 1, 2021).

Dharmaraj, S. 2020a. Angeles City, the Philippine intensifies COVID-19 contact tracing via app. OpenGov Asia. https://opengovasia.com/angeles-city-the-philippine-intensifies-covid-19-contact-tracing-via-app/ (accessed on June 9, 2021).

Dharmaraj, S. 2020b. Baguio aiming to be the first Smart City in the Philippines. OpenGov Asia. https://opengovasia.com/baguio-aiming-to-be-the-first-smart-city-in-the-philippines/ (accessed November 23, 2021).

Diangson, L. 2021. Converge to build PHP 1 billion data center in Cebu. YugaTech. https://www.yugatech.com/internet-telecoms/converge-to-build-php-1-billion-data-center-in-cebu/#sthash.4X9AIWlV.4rf0n3Ts.dpbs (accessed on October 21, 2021).

DICT. 2021a. Digital Cities ICT roadmaps target to create 100K provincial jobs. https://dict.gov.ph/digital-cities-ict-roadmaps-target-to-create-100k-provincial-jobs/ (accessed on November 15, 2021).

DICT. 2021b. Free Wi-Fi sites launched in 48 locations within Sorsogon. *freepublicwifi.gov.ph* (DICT). https://freepublicwifi.gov.ph/free-wi-fi-sites-launched-in-48-locations-within-sorsogon/ (accessed November 24, 2021).

DICT. 2021c, July 8. Digital Cities ICT roadmaps target to create 100K provincial jobs. DICT. https://dict.gov.ph/digital-cities-ict-roadmaps-target-to-create-100k-provincial-jobs/ (accessed November 25, 2021).

DICT. 2020a. NBP set to save gov't 720 million pesos in 2021. https://dict.gov.ph/nbp-set-to-save-govt-720-million-pesos-in-2021/ (accessed on November 14, 2021).

DICT. 2020b. DICT inks MOA with Baguio City to boost Smart City Project. *freepublicwifi.gov.ph* (DICT). https://freepublicwifi.gov.ph/dict-inks-moa-with-baguio-city-to-boost-smart-city-project/ (accessed on November 23, 2021).

DICT. 2020c. DICT, Lucena City boost partnership with Free Wi-Fi and Tech4ED launch. https://dict.gov.ph/dict-lucena-city-boost-partnership-with-free-wi-fi-and-tech4ed-launch/ (accessed on November 23, 2021).

DICT. 2020d. DICT's digital hub in Zamboanga City among 2020 WSIS champions. DICT. https://dict.gov.ph/dicts-digital-hub-in-zamboanga-city-among-2020-wsis-champions/ (accessed on November 23, 2021).

DICT. 2019a. *National ICT ecosystem framework.* Quezon City, Philippines: Department of Information and Communications Technology. https://dict.gov.ph/ictstatistics/wp-content/uploads/2019/05/National-ICT-Ecosystem-Framework.pdf (accessed on May 12, 2021).

DICT. 2019b. DICT, DILG, NICP award LGUs' outstanding digital initiatives. DICT. https://dict.gov.ph/dict-dilg-nicp-award-lgus-outstanding-digital-initiatives/ (accessed on November 23, 2021).

DICT. n.d.-a. Mandate, powers and functions. DICT. https://dict.gov.ph/about-us/our-mandate/ (accessed on June 27, 2021).

DICT. n.d.-b. Free Wifi for all. https://dict.gov.ph/freewifi/# (accessed on November 14, 2021).

DICT. n.d.-c. Frequently asked questions. https://data.gov.ph/?q=about_us (accessed on November 25, 2021).

DICT. n.d.-d. Open Data Philippines. https://data.gov.ph/ (accessed on November 25, 2021).

DICT. n.d.-e. e-Filipino Tech4Ed. DICT. https://dict.gov.ph/major-programs-and-projects/e-filipino/e-filipino-technology-for-the-economic-development-tech4ed/ (accessed on November 23, 2021).

DICT, DILG, and National ICT Confederation of the Philippines. 2020. Digital Governance Awards. https://ne-np.facebook.com/DGAwards/photos/a.643981532413044/1888004131344105 (accessed on October 18, 2021).

DILG. 2021. DILG to LGUs, public: Use StaySafe.PH app to boost contact tracing. DILG. https://dilg.gov.ph/news/DILG-to-LGUs-public-Use-StaySafePH-app-to-boost-contact-tracing/NC-2021-1062 (accessed November 25, 2021).

Dig, G. 2021. 12 unit's ng RxBox devices, nakatadang ipamahagi sa mga piling RHUs sa Region 2. RMN Networks. https://rmn.ph/12-units-ng-rxbox-devices-nakatakdang-ipamahagi-sa-mga-piling-rhus-sa-region-2/ (accessed on October 20, 2021).

Dig, G. 2020. No QR Code, No Entry Policy, ipatutupad sa Cauayan City. RMN Networks. https://rmn.ph/no-qr-code-no-entry-policy-ipatutupad-sa-cauayan-city/ (accessed on October 18, 2021).

DILG. 2013. Powers & functions. DILG. https://www.dilg.gov.ph/page/Powers-Functions/21 (accessed on June 27, 2021).

DILG, DTI, and DICT. Joint Memorandum Circular No. 1, Series of 2016. https://www.dilg.gov.ph/PDF_File/issuances/joint_circulars/dilg-joincircular-201696_bdac5d460e.pdf (accessed on November 25, 2021).

DLA Piper. 2021. Data protection laws of the world. https://www.dlapiperdataprotection.com/index.html?t=law&c=AE (November 10, 2021)

Domingo, L.C. 2021. Isabela State U launches telemedicine program to fight Covid-19 in Region 2. The Manila Times. https://www.manilatimes.net/2021/06/03/campus-press/isabela-state-u-launches-telemedicine-program-to-fight-covid-19-in-region-2/1801715 (accessed on October 20, 2021).

Domingo, L.C. 2016. Cauayan to build waste-to-energy plant. The Manila Times. https://www.manilatimes.net/2016/06/19/news/regions/cauayan-to-build-waste-to-energy-plant/268702 (accessed on October 20, 2021).

Domingo, L.C. and The Manila Times (2019). DoST introduces hybrid electric road train in Cauayan City. The Manila Times. https://www.manilatimes.net/2019/02/07/business/green-business/dost-introduces-hybrid-electric-road-train-in-cauayan-city/507928 (accessed on October 20, 2021).

DOST. 2021. CRADLE: Collaborative R&D to Leverage the Philippine Economy. https://s4cp.dost.gov.ph/programs/cradle/ (Accessed on November 13, 2021).

DOST. 2015. DOST Chief names Cauayan in Isabela as "smarter city". https://www.dost.gov.ph/index.php/knowledge-resources/news/44-2015-news/677-dost-chief-names-cauayan-in-isabela-as-smarter-city (accessed on October 20, 2021).

DOST-PCIEERD. 2021. DOST-PCIEERD launches 8 new data science R&D projects for good governance. https://pcieerd.dost.gov.ph/news/latest-news/417-dost-pcieerd-launches-8-new-data-science-r-d-projects-for-good-governance (accessed on November 27, 2021).

DOST-PCIEERD. 2020a. PCOO, DAP launch online course on gov't data acquisition. https://pcieerd.dost.gov.ph/news/latest-news/407-pcoo-dap-launch-online-course-on-gov-t-data-acquisition (accessed on November 15, 2021).

DOST-PCIEERD. 2020b, February 11. DOST, ADMU Build Smart Groundwater Monitoring Station in Iloilo. https://pcieerd.dost.gov.ph/news/latest-news/370-dost-admu-build-smart-groundwater-monitoring-station-in-iloilo (accessed November 24, 2021).

DOST-PCIEERD. 2020c. PATURO: Platform for Assessment and Tracking of Urbanization-Related Opportunities. http://projects.pcieerd.dost.gov.ph/project/8683 (accessed on October 20, 2021).

DOST-PCIEERD. n.d.-a. *DOST framework for smart sustainable communities and cities*. Taguig, Philippines: Department of Science and Technology – Philippine Council for Industry, Energy and Emerging Technology Research and Development. https://pcieerd.dost.gov.ph/images/pdf/2021/roadmaps/DOST%20Smarter%20City%20Framework_Final.pdf (accessed on May 12, 2021).

DOST-PCIEERD. n.d.-b. About the council. DOST-PCIEERD. https://pcieerd.dost.gov.ph/about-us/who-we-are (accessed on June 27, 2021).

DOST-PCIEERD. n.d.-c. 2023 call for proposals. https://pcieerd.dost.gov.ph/images/callforproposal/2021/regular_call/priority_areas/2023-Call-for-Proposals-revised.pdf (Accessed on November 13, 2021).

DOTr. 2019. NEDA Board oks DOTr's High Priority Bus System for Davao City. https://dotr.gov.ph/2014-09-02-05-03-02/55-dotrnews/1059-neda-board-oks-dotr-s-high-priority-bus-system-for-davao-city.html (accessed on September 28, 2021).

Electronic Information for Libraries (EIFL). n.d. Economic Wellbeing: Innovation Award. EIFL.
https://www.eifl.net/eifl-in-action/economic-wellbeing-innovation-award-4 (accessed on November 23, 2021).

Elgazzar, R.F. and R. El-Gazzar. 2017. Smart cities, sustainable cities, or both? – A critical review and synthesis of success and failure factors. In *Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2017)* 250-257. Setúbal, Portugal: SCITEPRESS – Science and Technology Publications, Lda. DOI: 10.5220/0006307302500257. https://www.scitepress.org/Papers/2017/63073/63073.pdf (accessed on May 11, 2021).

EO No. 2, Series of 2016. OPERATIONALIZING IN THE EXECUTIVE BRANCH THE PEOPLE'S CONSTITUTIONAL RIGHT TO INFORMATION AND THE STATE POLICIES TO FULL PUBLIC DISCLOSURE AND TRANSPARENCY IN THE PUBLIC SERVICE AND PROVIDING GUIDELINES THEREFOR. https://www.officialgazette.gov.ph/2016/07/23/executive-order-no-02-s-2016/ (accessed on November 25, 2021).

Flint, A. 2020. What Abu Dhabi's city of the future looks like now. Bloomberg CityLab. https://www.bloomberg.com/news/articles/2020-02-14/the-reality-of-abu-dhabi-s-unfinished-utopia (November 10, 2021).

Flora, I.A. 2021, October 16. San Fernando bats for most 'biz-friendly' award anew. SunStar Pampanga. https://www.sunstar.com.ph/article/1910347/Pampanga/Local-News/San-Fernando-bats-for-most-biz-friendly-award-anew (accessed on November 22, 2021).

Francisco, C.Q. 2018. P1B set for Davao underground cable project phase 2. BusinessWorld. https://www.bworldonline.com/p1b-set-for-davao-underground-cable-project-phase-2/ (accessed on September 28, 2021).

Gambrill, A. n.d. The Sta. Ana Public Market wastewater treatment plant sustainable green technology in the Philippines. USAID. https://2012-2017.usaid.gov/global-waters/march-2011/wastewater-treatment-plant (accessed on June 4, 2021).

Geronimo, A. 2021. Abu Dhabi, Singapore ally to accelerate smart city drive. ITP.net. https://www.itp.net/emergent-tech/97736-abu-dhabi-singapore-ally-to-accelerate-smart-city-drive (accessed on June 30, 2021).

Glasco, J. 2018. Smart City Zaragoza: The power of citizen innovators. Bee smart city. https://hub.beesmart.city/city-portraits/smart-city-zaragoza-the-power-of-citizen-innovators (accessed on November 9, 2021).

Globe. 2021. Globe builds 6 new sites for better Internet experience in Malabon. https://www.globe.com.ph/about-us/newsroom/corporate/globe-builds-6-new-sites-malabon.html#gref (accessed on October 21, 2021).

Gonzales, I. 2020. Makati seeks to become Philippines first smart city. The Philippine Star. https://www.philstar.com/business/2020/01/31/1989088/makati-seeks-become-philippines-first-smart-city (accessed on June 7, 2021).

Graffiquo. 2020. Remotely building a digital twin – Cauayan City – a pioneering example for ASEAN. https://graffiquo.com/remotely-building-a-digital-twin-cauayan-city-a-pioneering-example-for-asean/ (accessed on October 19, 2021).

GSMA. 2012. South Korea: Busan Green u-City. https://www.gsma.com/iot/wp-content/uploads/2012/08/cl_busan_08_121.pdf (accessed on November 9, 2021).

Guadalquiver, N. 2021, March 2021. Bacolod City mayor upbeat on new telecom investor. *Philippine News Agency*. https://www.pna.gov.ph/articles/1133875 (accessed on November 23, 2021).

Gunio, B. 2020. Angeles City to be next smart city. Manila Standard. https://manilastandard.net/index.php/lgu/luzon/334991/angeles-city-to-be-next-smart-city.html (accessed on June 9, 2021).

IMD and SUTD (2021). Smart city index 2021. https://www.imd.org/smart-city-observatory/home/#_smartCity (accessed on November 11, 2021).

IMD and SUTD (2020). Smart city index 2020. https://www.imd.org/smart-city-observatory/smart-city-index/ (accessed on May 25, 2021).

IMD and SUTD (2019). Smart city index 2019. https://www.imd.org/research-knowledge/reports/imd-smart-city-index-2019/ (accessed on December 1, 2021).

INQUIRER.net BrandRoom. 2020. City Government of Marikina taps Bayad Center to provide convenience for Marikenos. INQUIRER.NET. https://globalnation.inquirer.net/183043/city-government-of-marikina-taps-bayad-center-to-provide-convenience-for-marikenos (accessed on June 13, 2021).

Japan International Cooperation Agency. 2015. The Roadmap Study for Sustainable Urban Development in Metro Cebu. Makati City, Philippines: JICA Philippines.

Jayasena, N.S., H. Mallawaarachchi, and K.G.A.S. Waidyasekara. 2019. A critical review on the drivers and barriers for enabling smart cities. Proceedings of the International Conference on Industrial Engineering and Operations Management, Bangkok, Thailand, March 5-7, 2019. https://www.ieomsociety.org/ieom2019/papers/542.pdf (accessed on May 19, 2021).

Junio, R. 2021, August 27. Quezon City Successfully Rolls out Digital Tools For COVID-19 Response. *World Health Organization (WHO)*. https://www.who.int/philippines/news/detail/27-08-2021-quezon-city-successfully-rolls-out-digital-tools-for-covid-19-response (accessed on November 22, 2021).

Koh, D. 2017. EXCLUSIVE – Encouraging collaboration and sharing of knowledge within the government and beyond at the City of Quezon. https://opengovasia.com/exclusive-encouraging-collaboration-and-sharing-of-knowledge-within-the-government-and-beyond-at-the-city-of-quezon/ (accessed on June 5, 2021).

Kondepudi, S.N. 2014. Smart sustainable cities: An analysis of definitions. Focus group technical report. Geneva, Switzerland: International Telecommunication Union. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi7i9q_qsDwAhUIPXAKHbCcAaIQFjAAegQIAxAD&url=https%3A%2F%2Fwww.itu.int%2Fen%2FITU-T%2Ffocusgroups%2Fssc%2FDocuments%2FApproved_Deliverables%2FTR-Definitions.docx&usg=AOvVaw2tzL2wnbsb4L_OLPJXB6qX (accessed on May 11, 2021).

Kubina, M., D. Šulyová, and J. Vodák. 2021. Comparison of smart city standards, implementation and cluster models of cities in North America and Europe. Sustainability, 13(6), 3120. **https://doi.org/10.3390/su13063120**. https://www.mdpi.com/2071-1050/13/6/3120/pdf (accessed on November 13, 2021).

Kwang, B.K. and K. Minchae. 2021. South Korea - data protection overview. OneTrust DataGuidance. https://www.dataguidance.com/notes/south-korea-data-protection-overview (November 10, 2021).

Lalu, G.P. 2019. Makati City is a finalist for World Smart Cities Awards. https://newsinfo.inquirer.net/1181454/makati-city-is-a-finalist-for-world-smart-cities-awards (June 7, 2021).

LANDBANK. 2021. *Navotas City, LANDBANK team up for online tax payment service*. https://www.landbank.com/news/navotas-city-landbank-team-up-for-online-tax-payment-service (accessed on june 7, 2021).

LANDBANK. 2020. *Caloocan City LGU taps LANDBANK for online payment of taxes*. https://www.landbank.com/news/caloocan-city-lgu-taps-landbank-for-online-payment-of-taxes (accessed on June 16, 2021).

Lee, H.-J. 2020. 'Smart city' in Busan will start selecting its inhabitants. Korea JoongAng Daily. https://koreajoongangdaily.joins.com/2020/12/23/business/economy/kwater-smart-village-smart-technologies/20201223175900501.html (accessed on November 9, 2021).

Lena, P. 2019, October 29. Free Wi-Fi deal with Smart boosts Iloilo's 'smart city' goal. *Philippine News Agency*. https://www.pna.gov.ph/articles/1084562 (accessed on November 23, 2021).

Lena, P. 2018, June 25. Iloilo City to launch mobile app June 29. *Philippine News Agency*. https://www.pna.gov.ph/articles/1039399 (accessed on November 23, 2021).

Lim, M. 2020. Malabon launches online payment. Metro News Central. https://metronewscentral.net/malabon/metro-cities/malabon-launches-online-payment (accessed on November 23, 2021).

Llemit, R.L.G. 2021. City to make database of fully-vaxxed individuals. SunStar Davao. https://www.sunstar.com.ph/article/1903531/Davao/Local-News/Davao-City-Government-to-make-database-of-fully-vaxxed-individuals (accessed on November 6, 2021).

Llemit, R.L.G. 2020. Loss of network services due to fiber optic cut. SunStar Davao. https://www.sunstar.com.ph/article/1871122/Davao/Local-News/Loss-of-network-services-due-to-fiber-optic-cut (accessed on October 21, 2021).

Lopez, I.D. and B.S.V. Lapetra. 2021. Spain - data protection overview. OneTrust DataGuidance. https://www.dataguidance.com/notes/spain-data-protection-overview (November 10, 2021).

Lucas, D.L. 2020. Makati gets most efficient gov't award from global smart cities group. Philippine Daily Inquirer. https://business.inquirer.net/308918/makati-gets-most-efficient-govt-award-from-global-smart-cities-group (accessed on Jun 7, 2021).

Ludher, E., N. Sharda, R. Lal, Y. Xu, C. Chow, and J. Ng. 2018. *ASEAN Smart Cities Network.* Edited by P. Somasundram. Singapore: Centre for Liveable Cities, (CLC). https://www.clc.gov.sg/docs/default-source/books/book-asean-smart-cities-network.pdf (accessed on May 11, 2021).

Madrazo-Sta. Romana, J.J. 2012. Davao gov't, IBM push for 'smart city'. GMA News Online. https://www.gmanetwork.com/news/scitech/technology/263643/davao-gov-t-ibm-push-for-smart-city/story/ (accessed on June 8, 2021).

Malabon City Bids and Awards Committee. 2017. Invitation to bid: Supply and installation of CCTV cameras for emergency monitoring and response. http://malabon.gov.ph/wp-content/uploads/2018/02/CCTV-CAMERAS-MONITORING.pdf (accessed on October 21, 2021).

Malaya Business Insight. 2019. Grab, Valenzuela embark on PH's first smart city project. Malaya Business Insight. https://malaya.com.ph/index.php/news_business/grab-valenzuela-embark-on-phs-first-smart-city-project/ (accessed on June 16, 2021).

Mandaue City Government and DICT. n.d. https://staging.ebpls.com/mandauecitycebu/index.php/login (accessed on September 26, 2021).

Manila Bulletin. 2020. Makati eyes more PPPs in a bid to become the first PH 'smart city'. Manila Bulletin. https://mb.com.ph/2020/01/31/makati-eyes-more-ppps-in-a-bid-to-become-the-first-ph-smart-city/ (accessed on June 7, 2021).

Marasigan, A.J. 2019. Numbers don't lie. BusinessWorld. https://www.bworldonline.com/makatis-audacious-ambitions/ (accessed on June 7, 2021).

Marasigan, L.S. 2019. San Juan, 'smart city'. Businessmirror. https://businessmirror.com.ph/2019/11/15/san-juan-smart-city/ (accessed on June 6, 2021).

Marquez, C. 2019. San Juan City signs pact with telco firm for free Wi-Fi zones. INQUIRER.net. https://newsinfo.inquirer.net/1171869 (accessed on June 7, 2021).

McKinsey Global Institute. 2018. *Smart cities in Southeast Asia.* Discussion paper produced for World Cities Summit 2018 in collaboration with the Centre for Liveable Cities, Singapore. Singapore: McKinsey Global Institute. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Operations/Our%20Insights/Smart%20cities%20in%20Southeast%20Asia/MGI-Smart-Cities-in-SouthEast-Asia.PDF (accessed on May 15, 2021).

McNulty, E. n.d. What to do with brownfields. Smart Cities Dive. https://www.smartcitiesdive.com/ex/sustainablecitiescollective/interview-julie-bargmann-brownfields-diva/33606/ (accessed on June 30, 2021).

Melican, N.R. 2013. Malabon City computerizes data, transactions in tax collection. Philippine Daily Inquirer. https://newsinfo.inquirer.net/492739/malabon-city-computerizes-data-transactions-in-tax-collection (accessed on November 23, 2021).

Mercurio, R. 2021. Smart rolls out more free WiFi. *The Philippine Star*. https://www.philstar.com/business/2021/07/24/2114651/smart-rolls-out-more-free-wifi (accessed on November 22, 2021).

MindaNews. 2021, October 26. GenSan targets completion of P451M traffic light, CCTV project next year. MindaNews. https://www.mindanews.com/top-stories/2021/10/gensan-targets-completion-of-p451m-traffic-light-cctv-project-next-year/ (accessed November 2021).

Miranda, J. 2021. Davao City government uses QR coes as part of contact tracing. OpenGov Asia. https://opengovasia.com/davao-city-government-uses-qr-codes-as-part-of-contact-tracing-efforts/ (accessed on June 9, 2021).

Mocon-Ciriaco, C. 2017. Makati eyes becoming 'smart city'. Businessmirror. https://businessmirror.com.ph/2017/08/17/makati-eyes-becoming-smart-city/ (accessed on June 7, 2021).

Mouton, M. 2021. Worlding infrastructure in the global South: Philippine experiments and the art of being 'smart'. Urban Studies, SAGE Publications, 58(3), 621-638. DOI: 10.1177/0042098019891011. https://hal.archives-ouvertes.fr/hal-02977298/document (accessed on June 12, 2021).

MultiSys Admin. n.d. Cauayan City bags multiple awards for 'smart city' project with MultiSys. Multisys Technologies Corporation. https://www.multisyscorp.com/news/cauayan-city-bags-multiple-awards-for-smart-city-project-with-multisys (accessed on June 12, 2021).

Munchang, R. 2020. Electric scooters, ipinasakamay sa LGU Cauayan! RMN Networks. https://rmn.ph/electric-scooters-ipinasakamay-sa-lgu-cauayan/ (accessed on October 20, 2021).

Municipality of Carmona, Cavite. 2021. Carmona: The smart city. https://www.facebook.com/carmonalgu/videos/1220642585033131/ (accessed on June 27, 2021).

Nam, T. and T.A. Pardo. 2011. Conceptualizing smart city with dimensions of technology, people, and institutions. The proceedings of the 12th Annual International Conference on Digital Government Research. MD, USA: Association for Computing Machinery (ACM). https://inta-aivn.org/images/cc/Urbanism/background%20documents/dgo_2011_smartcity.pdf (accessed on May 11, 2021).

Navales, R.G. 2018. Mabalacat to roll out free WiFi project. Sunstar. https://www.sunstar.com.ph/article/1742687/Pampanga/Local-News/Mabalacat-to-roll-out-free-WiFi-project (accessed on June 9, 2021).

Nazario, D. 2021. Pasay City introduces 'Electronic Mamamayan ID' through its first-ever smart city ecosystem. *Manilla Bulletin*. https://mb.com.ph/2021/05/17/pasay-city-introduces-electronic-mamamayan-id-through-its-first-ever-smart-city-ecosystem/ (accessed on November 22, 2021).

Nazario, D. 2020. Taguig City launches 'TORCH' for easy transitioning post-ECQ. Manila Bulletin. https://mb.com.ph/2020/04/28/taguig-city-launches-torch-for-easy-transitioning-post-ecq-2/ (accessed on December 15, 2021).

Neola, J. 2021. Naga City, state university to develop zero-waste tech. Philippine News Agency. https://www.pna.gov.ph/articles/1135863 (accessed on June 8, 2021).

Newsbytes.PH. 2020. Manila city gov't deploying AI to analyze public complaints. Newsbytes.PH. https://newsbytes.ph/2020/02/16/manila-city-govt-deploying-ai-to-analyze-public-complaints/ (accessed on June 5, 2021).

Nicavera, E. 2020, January 29. ICT dev't in NegOcc component cities pushed. *Philippine News Agency*. https://www.pna.gov.ph/articles/1092345 (accessed November 24, 2021).

Noori, N., T. Hoppe, and M. de Jong. 2020. Classifying pathways for smart city development: Comparing design, governance and implementation in Amsterdam, Barcelona, Dubai, and Abu Dhabi. Sustainability 12(10), 1-24. doi:10.3390/su12104030. https://www.mdpi.com/2071-1050/12/10/4030/htm (accessed on May 22, 2021).

NPC. n.d. About us. https://www.privacy.gov.ph/about-us/ (accessed on November 18, 2021).

Olandres, A. 2015. Solar power farm in Valenzuela now operational. YugaTech. https://www.yugatech.com/news/solar-power-farm-in-valenzuela-now-operational/ (accessed on June 16, 2021).

Padillo, M. 2021. DLPC's underground cabling project 97 percent complete. Edge Davao. https://edgedavao.net/latest-news/2021/05/08/dlpcs-underground-cabling-project-97-percent-complete/ (accessed on September 28, 2021).

Padillo, M.M. 2020. Davao City partners with tech firm Fusionex for e-halal hub. BusinessWorld. https://www.bworldonline.com/davao-city-partners-with-tech-firm-fusionex-for-e-halal-hub/ (accessed on October 26, 2020).

Palaubsanon, M.L. 2019. No contact apprehension of traffic violators pushed in Mandaue. The Freeman. https://www.philstar.com/the-freeman/cebu-news/2019/11/26/1971956/no-contact-apprehension-traffic-violators-pushed-mandaue (accessed on October 21, 2021).

Park, S.-J. 2021. Busan to set up barrier-free public transportation environments for disabled. Aju Business Daily. https://www.ajudaily.com/view/20210303094059631 (November 9, 2021).

PayMaya. n.d. Manila City rolls out PayMaya-enabled citizen IDs, 'cashless' Kadiwa stores. https://enterprise.paymaya.com/press-release/manila-city-roll-out-paymaya-enabled (accessed on June 5, 2021).

Peng, R.X. 2019. Urban competitiveness and the smart city: An empirical analysis in a developing country context. TPRC47: The 47th Research Conference on Communication and Internet Policy 2019. http://dx.doi.org/10.2139/ssrn.3445732 . https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3445732 (accessed on May 19, 2021).

Perez, A.J.R.S. 2019. Project to bring Mindanao $10B. SunStar. https://www.sunstar.com.ph/article/1823289/Davao/Business/Project-to-bring-Mindanao-$10B (accessed on June 9, 2021).

PINAS. 2020. DOST turns over e-scooters to Cauayan City for 'smarter mobility'. https://pinasglobal.com/2020/02/dost-turns-e-scooters-cauayan-city-smarter-mobility/ (accessed on October 20, 2021).

Poon, Y.X. and F. Shiyuan. 2019. How this agricultural town became the Philippines' first 'smart city': Interview with Bernard Faustino Dy, Mayor of Cauayan. GovInsider. https://govinsider.asia/digital-gov/how-this-agricultural-town-became-the-philippines-first-smart-city/ (accessed on June 11, 2021).

PPP Center. n.d.-a. Mandate, vision and mission. PPP Center. https://ppp.gov.ph/about-the-ppp-center/ (accessed on June 27, 2021).

PPP Center. n.d.-b. Projects database. https://ppp.gov.ph/project-database/ (accessed on November 27, 2021).

PPP Center. n.d.-c. Public-Private Partnership Governing Board: Guidelines on the identification, selection, and prioritization of Public-Private Partnership (PPP) Project. https://ppp.gov.ph/wp-content/uploads/2018/07/PPPC_GUIDE-Identification-Selection-Prioritization-20150325.pdf (accessed on November 27, 2021).

PPP Center. n.d.-d. Davao No Contact Apprehension Project. https://ppp.gov.ph/ppp_projects/davao-no-contact-apprehension-project/ (accessed on October 15, 2021).

PPP Center. n.d.-e. Tagum City Waste-to-Energy Plant Project. https://ppp.gov.ph/ppp_projects/tagum-city-waste-to-energy-plant-project/ (accessed on November 23, 2021).

Presidential Communications Operations Office (PCOO). 2021. Duterte Administration Year-End Report 2020. Manila City, Philippines: Presidential Communications Operations Office. https://mirror.pcoo.gov.ph/wp-content/uploads/2020/12/Duterte-Administration-Year-End-Report-2020-DEC30-1030PM.pdf (accessed November 25, 2021).

PSA. 2021a. Philippine Standard Geographic Code (PSGC): Province of Isabela – Code:023100000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/023100000 (accessed on October 22, 2021).

PSA. 2021b. Philippine Standard Geographic Code (PSGC): Province of Cagayan – Code:021500000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/021500000 (accessed on October 22, 2021).

PSA. 2021c. Philippine Standard Geographic Code (PSGC): Province of Pampanga – Code:035400000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/035400000 (accessed on October 22, 2021).

PSA. 2021d. Philippine Standard Geographic Code (PSGC): National Capital Region (NCR) – Cities. https://psa.gov.ph/classification/psgc/?q=psgc/cities/130000000 (accessed on October 22, 2021).

PSA. 2021e. Philippine Standard Geographic Code (PSGC): Province of Cebu – Code:072200000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/072200000 (accessed on October 22, 2021).

PSA. 2021f. Philippine Standard Geographic Code (PSGC): Province of Davao del Sur – Code:112400000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/112400000 (accessed on October 22, 2021).

PSA. 2021g. Philippine Standard Geographic Code (PSGC): Province of Davao del Norte – Code:112300000. https://psa.gov.ph/classification/psgc/?q=psgc/citimuni/112300000 (accessed on October 22, 2021).

PSA. 2021h. About OpenStat. https://openstat.psa.gov.ph/About (accessed on November 25, 2021).

PSA. 2021i. Databases. https://openstat.psa.gov.ph/Database (accessed on November 25, 2021).

PSA 2021j. Philippine Standard Geographic Code (PSGC): City of Cauayan – Code:023108000. https://psa.gov.ph/classification/psgc/?q=psgc/barangays/023108000 (accessed on December 1, 2021).

PSA. 2019. https://psa.gov.ph/content/urban-population-philippines-results-2015-census-population (November 10, 2021).

PSA. n.d. Tech4Ed Project Brief. PSA. https://psa.gov.ph/sites/default/files/7.6.3%20Tech4Ed.pdf (accessed on November 23, 2021).

Quadra-Balibay, A. 2020. PHLPOST deploys "Green Delivery" electric vehicles for relief operations in Pasig City. https://www.goodnewspilipinas.com/phlpost-deploys-green-delivery-electric-vehicles-for-relief-operations-in-pasig-city/ (accessed on June 5, 2021).

Ramaprasad, A., A. Sánchez-Ortiz, and T. Syn. 2017. A unified definition of a smart city. 16th International Conference on Electronic Government (EGOV). https://hal.inria.fr/hal-01702978/document (accessed on May 13, 2021).

Ranada, P. 2020. Pasig uses online tech to consult residents on 'open streets' proposal amid pandemic. https://www.rappler.com/nation/pasig-city-uses-polis-consult-residents-open-streets-proposal (accessed on June 16, 2021).

Republic Act No. 10173. AN ACT PROTECTING INDIVIDUAL PERSONAL INFORMATION IN INFORMATION AND COMMUNICATIONS SYSTEMS IN THE GOVERNMENT AND THE PRIVATE SECTOR, CREATING FOR THIS PURPOSE A NATIONAL PRIVACY COMMISSION, AND FOR OTHER PURPOSES. Metro Manila: Congress of the Philippines. https://www.privacy.gov.ph/data-privacy-act/ (accessed on November 13, 2021).

Republic Act No. 10929. AN ACT ESTABLISHING THE FREE INTERNET ACCESS PROGRAM IN PUBLIC PLACES IN THE COUNTRY AND APPROPRIATING FUNDS THEREFOR. Metro Manila: Congress of the Philippines. http://legacy.senate.gov.ph/republic_acts/ra%2010929.pdf (accessed on November 14, 2021).

Republic Act No. 11032**.** AN ACT PROMOTING EASE OF DOING BUSINESS AND EFFICIENT DELIVERY OF GOVERNMENT SERVICES, AMENDING FOR THE PURPOSE REPUBLIC ACT NO. 9485, OTHERWISE KNOWN AS THE ANTI-RED TAPE ACT OF 2007, AND FOR OTHER PURPOSES. Metro Manila: Congress of the Philippines. https://www.officialgazette.gov.ph/2018/05/28/republic-act-no-11032/ (accessed on December 1, 2021).

Republic of the Philippines. n.d. Frequently asked questions. https://www.foi.gov.ph/help (accessed on November 25, 2021).

Rita, J. 2021, September 14. Nearly 11,000 free WiFi sites already installed nationwide —DICT. *GMA News Online*. https://www.gmanetwork.com/news/scitech/technology/803218/nearly-11-000-free-wifi-sites-already-installed-nationwide-dict/story/ (accessed November 25, 2021).

Sagarino, M.R. 2021. Cortes: Three more bike stations for Mandaue. Cebu Daily News. https://cebudailynews.inquirer.net/379867/cortes-three-more-bike-stations-for-mandaue (accessed on November 25, 2021).

Sánchez-Corcuera, R., A. Nuñez-Marcos, J. Sesma-Solance, A. Bilbao-Jayo, R. Mulero, U. Zulaika, G. Azkune, and A. Almeida. 2019. Smart cities survey: Technologies, application domains and challenges for the cities of the future. *International Journal of Distributed Sensor Networks* 15(6). https://journals.sagepub.com/doi/pdf/10.1177/1550147719853984 (accessed on May 12, 2021).

Santiagudo, E. 2019, August 17. 'INNOVATE ILOILO': Movement eyes Iloilo as innovation hub by 2030. *Daily News*. https://dailyguardian.com.ph/innovate-iloilo-movement-eyes-iloilo-as-innovation-hub-by-2030/ (accessed on November 24, 2021).

See, D.A. 2021. Firm proposes P2.2 billion Baguio Smart City project. https://www.baguioheraldexpressonline.com/firm-proposes-p2-2-billion-baguio-smart-city-project/ (accessed November 23, 2021).

Seow, J. 2017. Manila's new smart city run by artificial intelligence. https://www.indesignlive.hk/articles/projects/manilas-new-smart-city-run-artificial-intelligence (accessed on June 11, 2021).

Smart Cities World Forums. 2019. Metro Manila prepares for digital transformation with new smart city projects. Smart Cities World Forums. https://www.smartcitiesworldforums.com/news/smart-cities-asia-pacific/smart-infrastructure-ap/1267-metro-manila-prepares-for-digital-transformation-with-new-smart-city-projects (accessed on June 7, 2021).

Smart Communications. 2021. Smart Barangay Connect expands to more cities in PH. https://smart.com.ph/About/newsroom/full-news/2021/07/26/smart-barangay-connect-expands-to-more-cities-in-ph (accessed on November 23, 2021).

Smart Communications. 2019a. Smart powers San Fernando City Hall with Google Station. Smart. https://smart.com.ph/About/newsroom/full-news/2019/11/29/smart-powers-san-fernando-city-hall-with-google-station (accessed on June 16, 2021).

Smart Communications. 2019b. Cauayan to spark national 'smart city' movement. Smart. https://smart.com.ph/About/newsroom/full-news/2019/10/07/cauayan-to-spark-national-smart-city-movement (accessed on June 11, 2021).

SMART Public Affairs. 2021a, June 21. PLDT, Smart roll out more fiber, more cell sites in Palawan, fire up 5G. *Smart Communications, Inc*. https://smart.com.ph/About/newsroom/full-news/2021/06/21/pldt-smart-roll-out-more-fiber-more-cell-sites-in-palawan-fire-up-5g (accessed on November 23, 2021).

SmartCitiesWorld News Team. 2018. Abu Dhabi completes smart city project. SmartCitiesWorld. https://www.smartcitiesworld.net/news/news/abu-dhabi-completes-smart-city-project-3465 (accessed on June 30, 2021).

Speed Magazine. 2020. Grab, Navotas team up to provide jobs to 500 trike drivers. https://www.speedmagazine.ph/grab-navotas-team-up-to-provide-jobs-to-500-trike-drivers/ (accessed on June 7, 2021).

Spencer, B. 2020. Orange creates Abu Dhabi smart city app. ITS International. https://www.itsinternational.com/its6/products/orange-creates-abu-dhabi-smart-city-app (accessed on June 30, 2021).

Stübinger, J., and L. Schneider. 2020. Understanding smart city – a data-driven literature review. Sustainability, 12(20), 8460. **https://doi.org/10.3390/su12208460 (accessed on November 11, 2021).**

Suarez, J. 2018. 911 app now available. Mindanao Times. https://mindanaotimes.com.ph/2018/07/21/911-app-now-available/ (accessed on December 1, 2021).

SunStar Cebu. 2021. Mandaue City extends business permit renewal. https://www.sunstar.com.ph/article/1882941/Cebu/Local-News/Mandaue-City-extends-business-permit-renewal (accessed on September 26, 2021).

SunStar Cebu. 2019. Mandaue cited for emergency response system. SunStar Cebu. https://www.sunstar.com.ph/article/1834122/Cebu/Local-News/Mandaue-cited-for-emergency-response-system (June 8, 2021).

SunStar Cebu. 2018. Mandaue City gets 'Guardian' for emergency situations. https://www.sunstar.com.ph/article/1774615/Cebu/Local-News/Mandaue-City-gets-Guardian-for-emergency-situations (accessed on October 20, 2021).

SunStar Pampanga. 2019a. San Fernando, Smart partner for free public Wi-Fi. https://www.sunstar.com.ph/article/1834337/Pampanga/Local-News/San-Fernando-Smart-partner-for-free-public-Wi-Fi (accessed on October 21, 2021).

SunStar Pampanga. 2019b. San Fernando delivers business permits via courier. https://www.sunstar.com.ph/article/1810460/Pampanga/Local-News/City-of-San-Fernando-delivers-business-permits-via-courier (accessed on October 21, 2021).

Sy, S., A. Araneta, H. Rahemtulla, B. Carrasco, and S. Balgos. 2021. Mapping Digital Poverty in the Philippines using AI/Big Data and Machine Learning. Thinking Machines and ADB. https://stories.thinkingmachin.es/mapping-digital-poverty-in-the-philippines/ (accessed November 24, 2021).

Tagum City Government. 2018. Tagum commences traffic signalization project. https://tagumcity.gov.ph/tagum-commences-traffic-signalization-project/ (accessed on November 23, 2021).

Tagum City Information Office. 2018. Multi-purpose tech station launched in Tagum. City Government of Tagum. https://tagumcity.gov.ph/multi-purpose-tech-station-launched-in-tagum/ (accessed on June 9, 2021).

Talisic, B.B. and Sotto, J.M.O. 2018. Cebu's traffic lights. Cebu Daily News. https://cebudailynews.inquirer.net/196127/cebus-traffic-lights (accessed on October 21, 2021).

Tan, M. 2021. Cauayan City navigates typhoon damage with help of Singapore startup Graffiquo. https://www.businesstimes.com.sg/asean-business/cauayan-city-navigates-typhoon-damage-with-help-of-singapore-startup-graffiquo (accessed on October 19, 2021).

Tan, S.Y. and A. Taeihagh. 2020. Smart city governance in developing countries: A systematic literature review. Sustainability 12(899), 1-29. doi:10.3390/su1203089. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj-xprni9XwAhWNOnAKHTx5CJcQFjARegQIDxAD&url=https%3A%2F%2Fwww.mdpi.com%2F2071-1050%2F12%2F3%2F899%2Fpdf&usg=AOvVaw1kb-phS2TFBxk1Y9AEqFb2 (accessed on May 19, 2021).

Tecson, Z. 2018. San Fernando City embarks on infra 'smart city' projects. Philippine News Agency. https://www.pna.gov.ph/articles/1030996 (accessed on June 16, 2021).

The Economist. 2017. Davao City. Startup My City. https://startupmycity.economist.com/davao-city/ (accessed on June 8, 2021).

The Good News Pilipinas Team. 2018. Pasig City's smart public safety system, one of Asia's best. Good News Pilipinas. https://www.goodnewspilipinas.com/pasig-citys-smart-public-safety-system-one-of-asias-best/ (accessed on June 16, 2021).

The Manila Times. 2020. Pointing the way to a smarter city. https://www.manilatimes.net/2020/02/16/public-square/pointing-the-way-to-a-smarter-city/686213 (accessed on October 20, 2021).

Toli, A.M. and N. Murtagh. 2020. Concept of sustainability in smart city definitions. *Frontiers in built environment* 6(77):1-10. doi: 10.3389/fbuil.2020.00077. https://www.frontiersin.org/articles/10.3389/fbuil.2020.00077/full (accessed on May 13, 2021).

Tuguegarao City Government. 2021a. Tuguegarao City wins Digital Governance Awards 2020. https://tuguegaraocity.gov.ph/Tuguegarao%20City%20wins%20Digital%20Governance%20Awards%202020/182 (accessed on November 22, 2021).

Tuguegarao City Government. 2021b. Online services. https://tuguegaraocity.gov.ph/online-services/144 (accessed on November 22, 2021).

Tuquero, L. 2019. Future of gov't transactions? Valenzuela City launches online permit system. Rappler. https://www.rappler.com/business/valenzuela-city-launches-online-permit-system-november-2019 (accessed on June 16, 2021).

Umali, T. 2019. DICT rolls out free Wi-Fi for all program in pilot city. Opengovasia. https://opengovasia.com/dict-rolls-out-free-wi-fi-for-all-program-in-pilot-city/ (accessed on June 7, 2021).

UP Diliman Electrical and Electronics Engineering Institute. n.d. Rapid electric vehicle charging – Charging in Minutes (CharM). https://www.eee.upd.edu.ph/?q=news/charm-project (accessed on October 20, 2021).

USAID. 2021. CDI cities and DOST-PHIVOLCS ink partnership for climate and disaster resilience. USAID. https://surge.shorthandstories.com/mar2021/index.html#article (accessed on November 24, 2021).

Valencia, F. 2018. Mandaluyong taps PLDT Enterprise to speed up digital transformation. Newsbytes.PH. https://newsbytes.ph/2018/05/16/mandaluyong-taps-pldt-enterprise-to-speed-up-digital-transformation/ (accessed on June 5, 2021).

Veselitskaya, N., O. Karasev, and A. Beloshitskiy. 2019. Drivers and barriers for smart cities development. Theoretical and empirical researches in urban management 14(1), 85-110. https://www.jstor.org/stable/10.2307/26590931 (accessed on May 19, 2021).

Villanueva, R. 2008. Pasay City goes hi-tech with new CCTVs. Philstar Global. https://www.philstar.com/metro/2008/04/08/54689/pasay-city-goes-hi-tech-new-cctvs (accessed on June 8, 2021).

Visaya, Jr., V. 2020. Drones deployed as Cauayan City reports 1st Covid-19 case. Philippine News Agency. https://www.pna.gov.ph/articles/1099744 (accessed on October 20, 2021).

Woetzel, J., J. Remes, B. Boland, K. Lv, S. Sinha, G. Strube, J. Means, J. Law, A. Cadena, and V. von der Tann. 2018. Smart cities: Digital solutions for a more livable future. McKinsey Global Institute. https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/smart%20cities%20digital%20solutions%20for%20a%20more%20livable%20future/mgi-smart-cities-full-report.pdf (accessed on May 17, 2021)

World Bank Group. 2021. Smart city solutions and technologies. Open Learning Campus.

Wu, W., D. Zhu, W. Liu, C.-H., Wu. 2020. Empirical research on smart city construction and public health under information and communications technology. Socio-economic planning sciences. https://doi.org/10.1016/j.seps.2020.100994. https://reader.elsevier.com/reader/sd/pii/S0038012120308314?token=727D5D0D476466B1269C9A033BC34BF004F0055E77E9363F39571E72DA1D0C979222CF8D4144C699A97E8E6486433C1E&originRegion=eu-west-1&originCreation=20210519015024 (accessed on May 19, 2021).

Yoon, S.Y., H.S. Lee, T. Zelt, U. Narloch, and E. Aguirre. 2020. Smart city pathways for developing Asia: An analytical framework and guidance. ADB sustainable development working paper series no. 71. Mandaluyong City, Philippines: Asian Development Bank. https://www.adb.org/sites/default/files/publication/673441/sdwp-071-smart-city-pathways-developing-asia.pdf (accessed on May 13, 2021).

Yun Xuan, P. 2021. How a Philippines city uses digital twins for disaster recovery. GovInsider. https://govinsider.asia/climate/cauayan-graffiquo-how-a-philippines-city-uses-digital-twins-for-disaster-recovery/ (accessed on October 19, 2021).

Zaragoza Ayuntamiento. n.d. Open government strategy in the digital city 2012-2015. https://www.zaragoza.es/contenidos/sectores/tecnologia/Estrategia-Ciencia-Tecnologia-en.pdf (accessed on November 9, 2021).