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Developing a smart city framework for Philippine LGUs: A policy-driven approach to digital transformation

Leovigilda L. Bithay[1], Amelia Girly L. Aranas[2], Thea L. Aranas[3], Kenneth L. Armas[4*]
[1]Leovigilda L. Bithay- Cebu Technological University, Philippines; leovigilda.bithay@ctu.edu.ph (L.L.B.).
[2]Amelia Girly L. Aranas- Cebu Technological University, Philippines; ameliagirly.aranas@ctu.edu.ph (A.G.L.).
[3]Thea L. Aranas- Cebu Technological University, Philippines; instructorthea.aranas24@gmail.com (T.L.A.).
[4]Kenneth L. Armas- Nueva Ecija University of Science and Technology, Philippines; kennetharmas@neust.edu.ph (K.L.A.).

Abstract: Smart city development in the Philippines has gained momentum as local government units (LGUs) increasingly leverage digital technologies to enhance governance and service delivery. However, a tailored framework to guide this transformation at the LGU level remains lacking. This study proposes an integrative smart city framework for Philippine LGUs, grounded in policy-driven digital transformation and informed by global and regional models. The study is anchored in an empirical analysis of smart city readiness indicators and a detailed case study of a pilot LGU in Central Luzon. The study introduces the smart city concept and reviews existing frameworks, including the ASEAN Smart Cities Network (ASCN) Framework, the Department of Science and Technology (DOST) Smarter City Framework, ISO 37106:2021 guidelines, and the Asian Development Bank (ADB) smart cities pathway model. The researchers selected key smart city indicators—such as infrastructure, connectivity, governance, and innovation—using publicly available datasets, including the national census and the Cities and Municipalities Competitiveness Index. These indicators were used to assess the digital readiness of the case study LGU. The analysis reveals the pilot LGU's strengths, including the presence of an established ICT plan and active e-governance initiatives, alongside critical gaps such as limited investment in research and development. These reflect common challenges faced by emerging smart cities in the Philippines. The study explores the policy, institutional, and technological enablers essential for LGUs' digital transformation. Key enablers include national policy support, adoption of standards, local leadership, data infrastructure, and multi-stakeholder partnerships. The researchers present a proposed smart city framework for Philippine LGUs that balances quality of life, economic competitiveness, and environmental sustainability through integrated urban planning and adaptive governance. Policy recommendations are offered to both national agencies and LGUs to facilitate the operationalization of this framework, with the goal of aligning local smart city initiatives with broader development objectives and promoting sustainable, inclusive digital transformation.

Keywords: *Digital transformation, E-governance, Local government units (LGUs), Smart city framework, Urban innovation.*

1. Introduction

Urbanizing centers around the world are increasingly turning to "smart city" strategies to enhance governance, service delivery, and citizens' quality of life through technology and innovation [1]. A smart city is broadly defined as an innovative urban area that leverages digital technologies and data to improve the efficiency of city services and the welfare of its citizens [2]. In Southeast Asia, the Association of Southeast Asian Nations (ASEAN) has promoted regional collaboration through the ASEAN Smart Cities Network (ASCN), a platform unifying smart city development efforts across member countries [3]. The ASCN was launched in 2018 with 26 pilot cities (including Cebu City,

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* Correspondence: kennetharmas@neust.edu.ph

Davao City, and Manila for the Philippines) and established the ASEAN Smart Cities Framework as a non-binding guide for member citie [3]. This framework envisions a smart city in ASEAN as one that balances three interdependent strategic outcomes – High Quality of Life, Competitive Economy, and Sustainable Environment – underpinned by integrated master planning and dynamic, adaptive governance [4]. It recommends cities implement initiatives in six focus areas: Civic and Social, Health and Well-being, Public Safety and Security, Quality Environment, Built Infrastructure, and Industry and Innovation, supported by key enablers such as digital infrastructure, technological applications, partnerships, and funding [3]. These elements reflect ASEAN's collective vision for smart and sustainable urbanization, tailored to each city's unique needs and cultural context [4].

The Philippines, as a member of ASCN, has embraced the smart city concept at both national and local levels. The DOST Smarter City Framework (formulated by the DOST-PCIEERD) provides a comprehensive guide for developing "smart, sustainable communities and cities" in the Philippine context [5]. This framework emphasizes leveraging science and technology to build data infrastructure, integrate data into city management tools, and spur innovation to address complex urban problems. It outlines desired outcomes across multiple domains – from economic opportunity and education to environmental quality and governance – and identifies indicators to measure progress in each area. For example, in the Economic Opportunity domain, outcomes include increased employment opportunities and streamlined business processes, with indicators such as unemployment rate, poverty incidence, and number of new businesses and patents. Similar outcome-indicator sets are defined for education, health, public safety, infrastructure, mobility, and other sectors, aligning smart city goals with sustainable development objectives and United Nations Sustainable Development Goals [5, 6]. The DOST framework thus gives Philippine cities a localized blueprint for smart city development, stressing the importance of data-driven governance, citizen-centric services, and inclusive innovation.

International standards also inform smart city development strategies. International Organization for Standardization [7] (Sustainable Cities and Communities – Guidance on establishing smart city operating models) provides a global benchmark for city governments looking to transition to "smart" operating paradigms. It highlights the need to invest in "smart data" – ensuring that data on city assets and services are collected in real time and made available on open, interoperable platforms – to enable integrated planning and real-time service optimization [8]. The ISO guidelines advise treating city data as a strategic asset, fostering community-driven innovation through open data and civic participation, and pursuing city-led service integration so that citizens can access public services through one-stop, user-centric interfaces [7]. Additionally, ISO 37106 underscores the importance of establishing cross-cutting governance processes (breaking silos between departments), adopting flexible budgeting focused on public value rather than narrow line items, and ensuring multi-stakeholder engagement and accountability in implementing smart city initiatives [8]. These principles align closely with public administration best practices – emphasizing that technology must be accompanied by institutional innovation and policy reform to truly transform urban governance.

In parallel, development institutions like the ADB have explored how smart city concepts can be adapted to emerging economies in Asia. An ADB working paper on Smart City Pathways for Developing Asia proposes an analytical framework to guide cities in assessing their smart city readiness and formulating implementation roadmaps [9]. The framework views smart cities primarily as a means to improve access to and quality of urban services for citizens, businesses, and government through the strategic use of digital technologies [9]. Given the diversity of smart city initiatives, the ADB framework serves as a toolkit for policymakers to sift through abundant information, define local priorities, identify opportunities and barriers, link their strategies to actionable projects, and monitor progress systematically [9]. It draws from an extensive review of 150 smart city cases worldwide and 29 existing smart city models [9] extracting common elements such as key action fields (e.g., smart mobility, e-government, smart environment), essential enablers (policy support, finance, skills, and infrastructure), and step-by-step guidance for implementation [9]. Crucially, the ADB emphasizes that one-size-fits-all solutions do not apply – cities must tailor smart interventions to their specific context

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and capacities, often requiring incremental "pathways" rather than overnight transformation [9]. This perspective resonates strongly with the situation of Philippine cities, where resource levels and governance capacity vary widely across LGUs.

1.1. Research Objectives

This study was conducted to develop a policy-driven smart city framework tailored for Philippine local government units (LGUs) by examining existing models, assessing local digital readiness, and identifying key policy, institutional, and technological enablers that support sustainable and inclusive digital transformation. Specifically, the study aims to:

1. To examine existing global, regional, and national smart city frameworks (e.g., ASEAN Smart Cities Network, DOST Smarter City Framework, ISO 37106, and ADB Smart City Pathways) and identify their relevance and applicability to the Philippine local government context.
2. To assess the smart city readiness of a selected Philippine LGU (Pilot LGU) using a set of contextualized indicators across multiple dimensions such as infrastructure, connectivity, governance, innovation, and service delivery.
3. To identify the key policy, institutional, and technological enablers and barriers influencing the digital transformation efforts of Philippine LGUs.
4. To propose an integrative, policy-driven smart city framework tailored to the capacities, challenges, and development goals of Philippine LGUs.
5. To offer policy recommendations for national government agencies and local governments to support the implementation, sustainability, and scaling of smart city initiatives in the Philippines.

2. Methodology

2.1. Research Design

The researchers adopted a mixed-methods case study approach to develop and validate a smart city framework tailored for Philippine LGUs. The research design combined: (1) a quantitative assessment of smart city readiness indicators for the case study LGU (Pilot LGU), benchmarked against available data for other cities or national averages; and (2) a qualitative review of policy documents, frameworks, and case evidence to contextualize the findings and inform framework development.

2.2. Smart City Indicators and Data Sources

To quantitatively gauge smart city readiness, the researchers curated a set of indicators aligned with established frameworks (ASEAN, DOST, ISO), tailored to data availability for Philippine cities. These indicators span multiple dimensions:

1. Digital Infrastructure & Connectivity (e.g., household internet access, free Wi-Fi zones, broadband coverage),
2. Digital Governance & Services (e.g., existence of e-governance plans, online services, open data systems),
3. Human Capital & Innovation (e.g., ICT staff, innovation partnerships, ICT/R&D budget),
4. Policy and Institutional Support (e.g., smart city policies, local leadership, national program involvement), and
5. Service Outcomes (e.g., business permit efficiency, CCTV use, digital service satisfaction).

These indicators were largely consistent with the DOST Smart City Framework and ISO standards, particularly in governance and innovation metrics.

2.3. Data Sources

The researchers utilized publicly available datasets and reports, including:

1. Philippine Statistics Authority (PSA) census and surveys (e.g., internet access rates),

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2. Cities and Municipalities Competitiveness Index (CMCI) for LGU performance metrics such as innovation rankings and ICT planning,
3. Local government reports and news articles describing Pilot LGU's smart city initiatives (e.g., Wi-Fi projects, payment kiosks, public safety command center),
4. National policy documents and standards from DOST, DICT, and DILG, including the use of PNS ISO 37122:2020 and the DOST Smart City readiness framework.

2.4. Data Collection and Analysis

Quantitative data were collected on Pilot LGU's CMCI rankings and scores, estimated internet access rates, and participation in national digital initiatives. Institutional indicators were reviewed through local organizational structures and recognitions (e.g., Pilot LGU's ISO certifications and "Most Improved LGU" award). The analysis employed descriptive statistics and comparative assessments, using national benchmarks or top-performing cities for reference. Relationships among indicators were examined to reveal gaps between policy commitments and measurable outcomes. For instance, high rankings in ICT planning were compared with low R&D expenditures, highlighting gaps between planning and investment.

Validation of findings was performed by triangulating with literature and existing frameworks (e.g., ISO 37106, ADB Smart City Pathways). Comparative insights from neighboring LGUs in Central Luzon (e.g., Balanga, New Clark City) were also considered to contextualize challenges and extract scalable strategies.

3. Results and Discussion

3.1. Smart City Readiness Assessment of Pilot LGU

The analysis of Pilot LGU's readiness and progress towards becoming a smart city reveals a mixed landscape of significant strides and remaining gaps. Table 1 (described narratively below) summarizes the findings across key dimensions:

3.1.1. Digital Infrastructure & Connectivity

Pilot LGU enjoys relatively robust connectivity for a city outside Metro Manila. Although city-specific internet penetration data is not publicly disaggregated, Region III (Central Luzon) overall has one of the higher connectivity rates in the country. As of the 2020 Census, more than 50% of Philippine households have internet access, and urban areas like Angeles likely exceed this national averagepsa.gov.ph. Anecdotal evidence supports this – the city has been a beneficiary of telecom expansions and the presence of fiber internet providers due to its economic activity and proximity to the Clark Freeport Zone. The LGU itself has taken steps to boost connectivity: in 2020, Mayor Lazatin launched a project to provide free Wi-Fi in public areas and all 33 barangays [10]. By connecting households and public spaces (e.g., barangay halls, parks) via a city-wide Wi-Fi network, Angeles aimed to narrow the digital divide among its residents. While quantitative data on usage was not available at the time of study, the existence of this infrastructure is a key enabler for other smart city services (e.g., residents need internet access to use online government services).

3.1.2. E-Government Services and Platforms

Pilot LGU has made notable progress in digitizing its local government services. A flagship accomplishment was the deployment of digital payment kiosks across all barangays [10]. These kiosks allow residents to conduct transactions such as paying business taxes, real property taxes, and even settling traffic violation fines electronically, without needing to visit city hall. They were also installed in select private establishments like convenience stores to extend reach and convenience [10]. The Results of this initiative include improved revenue collection efficiency and reduced queues at government offices. Additionally, by late 2020 the city conducted pilot tests for cashless payments in public markets and jeepneys (public transport) [10]. This implies collaboration with fintech providers

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or banks to equip vendors and drivers with digital payment systems, moving towards a less-cash economy at the local level. The city also prides itself on having long ago computerized its revenue systems: it was the first LGU outside Metro Manila to earn an ISO 9001 certification back in 2002 for quality management in its electronic revenue collection [10]. That early investment laid a foundation for current e-governance improvements. As of the study period, most routine services (business permit applications, civil registry requests, etc.) in Angeles could be initiated online or at least electronically processed at point-of-service kiosks. However, integration of these various services into a single unified portal or app was still in progress – an area identified for future development to align with ISO 37106's recommendation of "one-stop" digital service access [7].

3.1.3. Policy and Institutional Framework

Pilot LGU demonstrates strong political will and planning for digital transformation. Crucially, it has an ICT/Smart City Strategic Plan – this is evidenced by its top rank in the CMCI "ICT Plan" indicator, where it scored the maximum points and ranked 1st among highly urbanized cities [11]. This suggests that the city has a formally adopted plan or strategy document guiding its ICT initiatives. The presence of such a plan typically means clear objectives (e.g., making all services digital by a target year), dedicated budget allocations for ICT projects, and a governing body or task force to implement it. Indeed, Pilot LGU has a functioning ICT Division (historically the Information Communication Technology Division since 2001 under a previous mayor) [10]. One of the mayor's advisers, IC Calaguas, who announced the smart city initiatives, was previously head of this ICT Division [10] indicating continuity and expertise in the team driving the projects. On the policy side, local legislation (such as city ordinances) has been supportive – for example, ordinances would have been needed to authorize electronic payments and to institutionalize the free Wi-Fi project. The city's compliance with national directives related to e-governance is high (CMCI ranks Angeles 5th in compliance to national directives among HUCs) [11] which could reflect adherence to DICT's cybersecurity and data privacy requirements, as well as alignment with DILG memoranda on Ease of Doing Business Act implementation (which mandates LGUs to automate permitting). This institutional preparedness – having plans, legal frameworks, and an organizational unit for ICT – is a critical component of readiness.

3.1.4. Human Capital and Innovation Capacity

In terms of skilled human resources, Pilot LGU benefits from being an education center (several universities and colleges in the city) and from talent spillovers from Clark Freeport (which hosts tech companies). The LGU's ICT division is staffed with IT professionals, and the city can also draw on DOST regional office support for training. However, one finding stands out: very low or zero R&D expenditure in the city's budget for innovation [11]. The CMCI data showed Angeles allocated no funds for R&D in the measured year [11] which is not uncommon for LGUs (many do not explicitly budget for R&D or innovation, beyond IT equipment purchases). This lack of dedicated funding could hinder sustained innovation – it indicates reliance on existing vendors or external grants for new tech solutions, rather than home-grown development or pilot testing new ideas. On the flip side, Pilot LGU's smart city push has garnered attention and likely partnerships. For instance, in 2021 the city hosted delegations from technology companies (e.g., FPT from Vietnam, Converge ICT which is a major fiber provider in the Philippines) to discuss smart solutionscitysurv.com. These visits signal that the city is networking internationally and with the private sector to bolster its innovation capacity. But tangible outputs of these engagements were not yet visible at the time of study.

Another indicator of innovation capacity is whether the city engages citizens in co-creation or open data. Angeles has not yet launched an open data portal, and citizen-facing innovation (like hackathons or civic tech challenges) were not reported. So, while the administrative capacity is there, citizen participation in innovation is still nascent. This is an area for development, aligning with the ASEAN

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framework's focus on "Civic and Social" initiatives and ISO's call for community-driven innovation via open data [8].

3.1.5. Public Safety and Resilience through Tech

A notable result of Pilot LGU's digital initiatives is the enhancement of its public safety infrastructure. The Pilot LGU Emergency and Disaster Command Center has been upgraded with digital surveillance capabilities [10]. This center aggregates live feeds from traffic cameras, emergency hotlines, and possibly GPS data from city vehicles, allowing for real-time monitoring of incidents. The improved command center likely contributed to the city's high rankings in Resiliency in CMCI – while Angeles ranked 28th overall in resiliency (perhaps due to other factors like disaster drills frequency), it was among the top performers in having a Disaster Risk Reduction Plan (ranked 2nd) [11]. The integration of technology in disaster and traffic management underpins these plans. The command center's expansion was funded by the mayor in a second phase, indicating ongoing improvements [10]. Although quantitative metrics (like reduction in response time or crime rate changes) were not available, the presence of this smart infrastructure is expected to improve outcomes such as faster emergency response and more efficient traffic management. It also builds citizen confidence in the smart city concept when they see tangible improvements in safety and convenience.

3.1.6. Economic Competitiveness and Quality of Life Outcomes

Ultimately, smart city initiatives aim to boost the economy and quality of life. Pilot LGU's competitiveness has indeed improved – it was recognized in 2023 as one of the Top 5 Most Improved Highly Urbanized Cities in the country [12]. This improvement suggests that the various reforms (not only digital but also perhaps ease-of-business and infrastructure projects) are yielding results. For example, if online business permitting reduced the time to get a permit from weeks to days, more businesses would be attracted, which could reflect in economic dynamism scores. The quality of life, while harder to measure, likely benefits from the smart city moves: free internet in communities can help students and professionals, cashless systems add convenience, and better traffic monitoring can reduce congestion. However, it's important to note that Angeles still trails larger cities in overall smart maturity – for instance, the pioneer smart cities in the Philippines like Manila or Cebu have larger-scale projects (Manila with its own command center and traffic system, Cebu with an ongoing metro-wide smart city program). Angeles is in a catch-up and leapfrog position: it has the advantage of learning from bigger cities and leveraging cheaper modern technology (like cloud services, IoT devices) to implement solutions quickly.

3.1.7. Statistical Highlights

While much of the above is descriptive, the researcherscan highlight a few quantitative points as statistical evidence of Pilot LGU's status:

1. Internet Access: National household internet access = 56.1%psa.gov.ph. Estimated Pilot LGU household internet access (based on urban regional data) ≈ 60–70%. This estimate is supported by the city's high urbanization; it would be useful in future to get exact figures from PSA or DICT surveys for Angeles.
2. Competitiveness Scores: Pilot LGU's overall CMCI score in 2022 placed it 25th of 33 HUCs [11]. By 2023, it was among most improved, implying its rank jumped (though exact 2023 rank not stated, improvement award suggests a significant score increase). The Innovation score was notable at 7.3254 (20th rank) with ICT Plan sub-score a perfect 2.00 (1st rank) [11].
3. Digital Services Uptake: The city reported (in local announcements) that thousands of transactions were processed via the kiosks within months of deployment. (Exact numbers were not published, but if The researchersassume even 50 people per barangay per month used the kiosks, that's ~1,650 transactions/month citywide, which previously might have crowded city hall.)

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4. Budget allocation: The share of the city budget for ICT is not separately published. However, capital investments like the Command Center expansion and kiosks procurement (possibly tens of millions of pesos) indicate a substantial allocation. Angeles in 2020 also invested in computerization of its vaccination registration and contact tracing apps during the COVID-19 response, reflecting agility in digital deployment.

These quantitative insights, though limited by data availability, confirm that Pilot LGU meets several prerequisites of a smart city (connectivity, e-services, plans and policies) but must address some quantitative gaps (inadequate R&D funding, moderate overall competitiveness rank relative to top cities, etc.).

3.2. Comparative Context within Central Luzon

Positioning Pilot LGU among Central Luzon LGUs provides further perspective. Central Luzon (Region III) is emerging as a competitive region; in 2023, 14 LGUs from Region III made it to the top 10 lists of various CMCI categories [12]. This includes not only Angeles but also cities like San Fernando (which ranked high in innovation), Tarlac City, Balanga City, and municipalities like Capas and Subic showing strengths in different pillars [12] pia.gov.ph. Pilot LGU's recognition as 5th Most Improved HUC nationwide is a testament to the region's upward trajectory [12]. The regional momentum likely creates a supportive environment: LGUs in Central Luzon can collaborate and share best practices through regional DILG and DTI networks. For example, Balanga City (Bataan) has advanced a smart city vision focusing on education and partnered with the Development Academy of the Philippines and DOST [12]. Such moves in the region underscore the importance of policy and institutional support: Balanga's case involved an academic partnership, Angeles engaged private tech companies – both show that multi-stakeholder collaboration is a key enabler, as also stressed in international frameworksrepository.unescap.orgrepository.unescap.org.

Pilot LGU, relative to these peers, seems to have chosen a broad-spectrum approach (touching many aspects: connectivity, payments, safety) rather than a narrow focus. This holistic approach aligns well with the notion that a smart city must simultaneously pursue improvements in economy, governance, environment, and living conditions [4]. The downside is it requires robust coordination and resources across all fronts – which brings us to the discussion of what policy, institutional, and technological factors need strengthening to sustain and scale Pilot LGU's (and other LGUs') smart city journey.

4. Discussion

The results from Pilot LGU's case study illustrate both the potential and challenges of local digital transformation in the Philippines. In this section, The researchersinterpret these findings through the lens of the frameworks and draw out broader implications. The discussion is organized into three thematic areas critical to developing a smart city framework for Philippine LGUs: (1) Policy and Governance Enablers, (2) Institutional and Human Capital Enablers, and (3) Technological Infrastructure Enablers. For each, the researchersintegrate insights from the ASCN, DOST, ISO, and ADB frameworks, as well as from the empirical evidence, to propose how LGUs can be guided in a structured manner. The researchersthen synthesize these into the proposed framework, followed by specific policy recommendations.

4.1. Policy and Governance Enablers

4.1.1. Strategic Vision and Planning

A clear policy vision at both national and local levels is foundational. Pilot LGU's success in developing an ICT plan and aligning it with its development goals exemplifies the importance of an LGU having its own Smart City Strategic Plan [11]. However, such local plans thrive when nested within a supportive national policy context. The Philippine national government, through DICT and DILG, has begun providing this context. DILG, for instance, encourages LGUs to adopt PNS

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[7] (Smart City Indicators) and the DOST Smart City Framework as reference models [13]. This is a critical policy enabler: by standardizing definitions and metrics of "smartness," the national government can ensure coherence and facilitate benchmarking across cities. Our framework therefore calls for LGU smart city plans aligned with national frameworks and international standards, ensuring that each city's vision contributes to common strategic outcomes (as ASCN defined: quality of life, economy, environment) [4].

Integrated Urban Development and Policy Coherence: The ASEAN framework emphasizes integrated master planning and adaptive governance as key systems [4]. For Philippine LGUs, this means smart city initiatives should be embedded in existing local development plans (Comprehensive Development Plans, land use plans) rather than treated as standalone ICT projects. Pilot LGU's efforts to integrate digital payments into traditional services is a good example of making smart solutions part of everyday governance. However, coordination is needed to avoid siloed projects. This is where DILG and NEDA (National Economic and Development Authority) can assist by issuing planning guidelines that require LGUs to address digital infrastructure, data management, and e-governance in their official development plans. Moreover, multilevel governance coordination is vital – aligning city projects with regional and national agencies. The ESCAP regional guidelines suggest effective multi-level coordination by clarifying institutional arrangements and data sharing channels between central and local governmentsrepository.unescap.orgrepository.unescap.org. In practice, this could mean: DICT providing an integrated data platform that LGUs can plug into for national services (e.g., national ID verification, vaccine certificates) and LGUs reporting their smart city progress to DILG for a national dashboard. Our framework envisions policy coherence where national strategies like the Philippine Digital Transformation Strategy or the National ICT Household Survey guide LGU priorities, and conversely, LGU innovations inform national policy updates.

Leadership, Champions, and Political Will: Policy-driven transformation requires champions. The presence of a forward-looking mayor in Pilot LGU who actively backed the smart city agenda was a decisive factor. The PIDS study on Philippine smart cities underscored that one indicator of readiness is the presence of smart city champions in the LGU [13] – individuals or offices that spearhead the cause. Our framework incorporates this by recommending that each LGU establish a Smart City Steering Committee led by a high-ranking official (e.g., the Mayor or a designated Smart City Officer akin to ASCN's Chief Smart City Officer concept [3]). This body would ensure continuous political support, inter-department coordination, and stakeholder engagement. The policy recommendation here is that DILG could formally encourage LGUs to designate such champions or committees, possibly through a memorandum or even by making it part of the Seal of Good Local Governance (SGLG) criteria in the future.

Accountability and Transparency: As LGUs digitalize, maintaining transparency and public trust becomes even more essential. The data collected and services provided must be transparent to avoid the perception of "black box" governance. PIDS notes that continuous support for smart city initiatives can only be attained through transparency and accountability in implementation [13]. For example, if a city deploys a traffic monitoring system, publishing congestion data or letting citizens see what the city sees can foster trust and encourage civic tech solutions. Pilot LGU and others should thus implement open data policies – making non-sensitive datasets (budget utilization, traffic data, environmental data) open to the public. The National Privacy Commission and DICT have roles to issue guidelines so that data sharing is done securely and respects privacy [13]. Our framework includes data governance policies as a pillar: LGUs should have a data privacy officer, follow standards for data interoperability (so that city data can feed into national platforms and vice versa), and commit to open data for accountability. The DOST-PCIEERD recommendation to incorporate an "accountability principle" in the smart city framework highlights the need for mechanisms like public dashboards tracking smart city KPIs and feedback loops for citizen input [13].

Regulatory Support and Funding Policies: Smart city projects often straddle public-private boundaries (e.g., telcos providing networks, fintech handling payments). National policy can ease

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implementation via enabling regulations – such as DICT's policies on common towers to improve telecom infrastructure, or BSP (Central Bank) regulations to encourage digital payments at local level. Additionally, funding policies matter: The national government could create a Smart City Fund or financing facility. While LGUs like Angeles used local funds, not all can afford it. The ADB framework suggests multilateral banks and external partners as important for financing [9]. Domestically, the Public–Private Partnership (PPP) Center is highlighted by PIDS as a resource to guide LGUs for feasibility studies and PPP projects in smart city development [13]. Our framework therefore positions policy support for financing as key: LGUs should be guided on accessing grants (e.g., DOST's Grants-in-Aid for smart cities), loans (MDB or domestic banks for infrastructure), or structuring PPPs for projects like city-wide fiber or smart lighting. For instance, a city could engage a PPP to install smart streetlights that also host Wi-Fi and sensors – national PPP guidelines can simplify this by listing smart city projects as priority eligible projects.

4.2. Institutional and Human Capital Enablers

Organizational Structures and Processes: Smart city initiatives often require breaking traditional bureaucratic silos and adopting a more agile, cross-cutting approach to service delivery. ISO 37106 advocates for city-wide governance processes and integrated management across departments [8]. In an LGU context, this means establishing inter-departmental teams for each major smart city project (for example, a team comprising the City Planning Office, ICT Division, Traffic Management, and Budget Office to implement an intelligent transport system). Pilot LGU's implementation of cashless payments involved coordination between the treasury (revenue), transport groups, and IT – requiring new workflows and training. Our framework emphasizes process re-engineering and integration: LGUs should review and streamline processes when introducing technology, otherwise they risk just computerizing red tape. The early ISO 9001 certification of Angeles' revenue offices in 2002 is a good illustration that having clear, efficient processes is a prerequisite to successful digitization [10]. Institutional readiness therefore includes quality management systems and the willingness to adjust organizational procedures to maximize tech benefits.

Capacity Building and Skills Development: Human capital is at the core of any digital transformation. LGUs need skilled personnel to plan, implement, and maintain smart city systems. The case study suggests Angeles had a head start by having an ICT division since 2001 and continuity in expertise [10]. Still, as new technologies emerge (IoT, AI analytics, cybersecurity challenges), continuous capacity development is necessary. The DOST has recognized this by training its regional offices to assist LGUs in smart city implementation. Our framework calls for a skills development program at the LGU level: training civil servants in data analytics, project management, and emerging tech. Partnering with universities in the region can help – e.g., Pilot LGU could partner with Holy Angel University or Angeles University Foundation to create courses or certificate programs for government staff on smart city management. The ASEAN framework's inclusion of "Industry and Innovation" and the DOST framework's emphasis on education and capacity (e.g., focus on STEM education, lifelong learning) are pertinent [5, 6]. By investing in its human capital, an LGU ensures that the technology procured will be utilized effectively and sustainably.

Moreover, knowledge exchange is an institutional enabler at the collective level. Cities should learn from each other's experiences – something ASCN facilitates internationally, and which could be replicated domestically. DILG and DICT could foster an LGU Smart City Network in the Philippines where cities like Makati, Cebu, Angeles, etc., share best practices, possibly through regular forums or an online knowledge portal. Such peer learning accelerates capacity building beyond formal training. This resonates with ESCAP's recommendation of multi-stakeholder collaboration and knowledge sharing, including peer-to-peer city collaborationrepository.unescap.orgrepository.unescap.org.

Stakeholder Engagement and Co-creation: Institutionally, the LGU must extend beyond government employees to engage citizens, businesses, and academia in the smart city journey. Pilot LGU's approach so far has been top-down (driven by the mayor's office). To sustain projects and ensure

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they meet real needs, a more participatory approach is beneficial. Citizen engagement can be achieved via public consultations on new tech policies (for example, educating and consulting transport groups before implementing cashless fares, which Angeles did to some extent), hackathons for local app developers to solve civic issues (not yet done in Angeles, but a recommendation), and feedback mechanisms (like rating city services apps). The concept of "co-production" of research and solutions mentioned in the DOST framework highlights bridging gaps between developers and end-users [5]. In our framework, The researchersencourage LGUs to create innovation labs or advisory councils that include civic tech groups, startup communities, and citizen representatives to ideate and test smart city solutions. This approach also nurtures local innovation ecosystems, ensuring solutions are appropriate to the local context. For instance, a local university might pilot a flood sensor network in a city barangay; involvement of the LGU from the start means promising pilots can scale city-wide.

Monitoring and Institutionalization: For longevity, smart city practices must be institutionalized so they do not depend solely on one leader or political term. This involves integrating key performance indicators (KPIs) into the LGU's performance monitoring. DILG could update its LGU performance scorecards to include digital governance metrics (some are already included under transparency and business friendliness criteria). Pilot LGU's big jump in competitiveness ranking suggests it likely institutionalized improvements that will remain beyond the current administration [12]. Our framework suggests establishing a smart city M&E (Monitoring and Evaluation) system at the LGU level: define KPIs (e.g., number of e-transactions, system uptime, user satisfaction), assign departments to report them, and review progress periodically in local development council meetings. This not only tracks progress but also holds the LGU accountable internally for maintaining the systems (e.g., ensuring those barangay kiosks are always functional, updating the city website, etc.). The ASCN Monitoring and Evaluation 2024 report shows how ASEAN cities track their project status (75% of ASCN projects were ongoing as of 2024) [14]. Philippine LGUs can emulate this by maintaining a registry of their smart city projects and their status, which could feed up to DILG for a national picture. PIDS even suggests an accreditation system eventually, where LGUs meeting certain smart city criteria get recognition or incentives [13]. This kind of institutional reinforcement through recognition can motivate LGUs to keep improving.

Collaborations and Partnerships: Institutionally, LGUs should not operate in isolation for such a complex undertaking. Partnerships, both public-public and public-private, are institutional enablers. Pilot LGU's outreach to tech companies is one example; others include tapping national agencies (like LTO for traffic system integration, DOE for smart grid pilots, etc.). The ASEAN and ADB frameworks stress partnerships – ASEAN lists Partnerships & Funding as a key enabler [3], ADB discusses the role of multilateral development banks and knowledge partnerships [9]. A practical step is for LGUs to enter into MOUs with academic and research institutions (for technical advice, as Balanga did with DAP and DOST [12]) and with private sector consortia (e.g., joining the Smart Cities Council or collaborating with local Chambers of Commerce for smart city hackathons). At the national level, building a marketplace of solutions can aid partnerships: for instance, DICT could certify certain solutions (like a particular e-governance software or a traffic sensor system) and create framework contracts that LGUs can readily use, thus reducing procurement hurdles.

4.3. Technological Infrastructure and Data Enablers

Technology is the most visible aspect of a smart city, but as the researchershave discussed, without the policy and institutional scaffolding, tech alone cannot deliver results. Here The researchersoutline the key technological enablers that our framework emphasizes for Philippine LGUs, in light of what was observed in Pilot LGU and recommended in the reference frameworks.

Digital Infrastructure (Connectivity and Hardware): The foundation is reliable digital infrastructure – primarily internet connectivity (both broadband and mobile) and electricity (as all smart systems depend on power). Pilot LGU's rollout of free Wi-Fi and the general improvement in broadband coverage in the area (thanks to telecom investments and fiber backbone expansions) provide a decent

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baseline. However, many LGUs, especially smaller ones, struggle with poor connectivity. Therefore, an LGU smart city framework for the Philippines must coordinate with national connectivity programs. The DICT's National Broadband Program and the Free Wi-Fi for All initiative are crucial; LGUs should leverage these by providing sites for Wi-Fi hotspots and encouraging community use. Our framework suggests that one of the first steps for any LGU is to map the connectivity gaps in its jurisdiction and work with providers or the national government to address them (e.g., identifying barangays with no fiber or 4G coverage). On hardware: LGUs need to invest in the core hardware for smart systems – servers (or cloud services), sensors (CCTVs, environmental sensors), and user devices (like the kiosks in Angeles). A guiding principle is interoperability and scalability: purchase systems that use open standards so they can integrate. For instance, if a city installs CCTVs now, it should ensure they can later integrate into a central video management system that could use AI – meaning choosing cameras with certain specs and network capabilities. ISO 37106 highlights investing in "smart data" and ensuring data is captured in real time [7] practically, this means equipping the city with IoT sensors and networks (e.g., LoRaWAN or others for IoT). Philippine LGUs might not individually implement these networks, but with guidance, provinces or regions could deploy shared IoT networks that cities can use (for example, a region-wide flood sensor network).

Data Platforms and Smart Data Management: Collecting data is one half; the other is managing and utilizing it. Pilot LGU's initiatives likely generated new data streams – digital payment records, traffic footage, etc. Without a good data management platform, these remain siloed. Our framework stresses establishing a City Data Platform or Dashboard. This could start simple: a data warehouse where different department databases feed in, and analytics tools to generate dashboards for city executives. Over time, it can incorporate big data techniques for predictive analytics (e.g., predicting traffic or flood incidents). The data platform should also provide open data access for transparency (with appropriate APIs or portals for public data), as mentioned in governance enablers. Some Philippine cities (like Quezon City or Cebu City) have begun building unified dashboards especially for COVID-19 response; extending those to broader city functions is the next step. A future-forward recommendation is exploring cloud infrastructure. Many LGUs might not afford large IT infrastructure, but cloud services (possibly through DICT's GovCloud or commercial providers) can allow them to deploy applications without heavy upfront costs. The framework should encourage LGUs to consider cloud-first solutions for scalability and security, provided they comply with government data regulations.

Standards and Interoperability: Technologically, adherence to standards ensures that as different systems come online, they work together. The reference to ISO 37122 (smart city indicators) in Philippine context means LGUs will be collecting data on similar metrics, enabling apples-to-apples comparisons [13]. But beyond indicators, standards like ISO 37106 guide how systems talk to each other. Our framework includes a principle of interoperability: e.g., if a city uses a certain vendor for its payment system and another for its transport card system, those should ideally be able to share data or merge into a single citizen account someday. The national government can help by issuing technical standards (DICT could update the e-Government Interoperability Framework to include smart city use cases).

Security and Resilience of Tech Systems: With more reliance on tech comes vulnerability. LGUs need to secure their systems against cyber threats. Pilot LGU handling digital payments raises questions of cybersecurity and data protection – presumably, they partnered with secure payment providers, but LGUs need capacity to at least enforce and monitor security. DICT's cybersecurity bureau and NPC's privacy guidelines are relevant; the framework must incorporate cybersecurity protocols (regular security audits, user access controls, data encryption for sensitive citizen data, etc.) and business continuity plans for tech (if systems fail, can the city revert to manual or have backups?). This ties into overall urban resilience. The ASCN framework's strategic outcome of "Sustainable Environment" includes resilience to disasters [3]; smart city tech should not become a single point of failure in crises. Encouraging cloud backup, redundant networks (e.g., having both fiber and wireless

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backups for critical communication) and training staff in fallback procedures is part of the tech enabler set.

Emerging Technologies for Local Context: One advantage Philippine LGUs have today is the availability of relatively low-cost emerging technologies that can be tailored to local problems. For instance, AI and data analytics can optimize traffic flows or predict crime hotspots; drone technology can assist in surveillance or mapping (some cities like Cauayan in Isabela have experimented with police drones and digital twin mapping [13]); blockchain might be used for land title management or transactions security in the future. Our proposed framework encourages LGUs (especially those more advanced like Angeles) to pilot such emerging tech on a small scale to test viability. The DOST can support through grants for pilot projects (e.g., a grant to develop a local traffic AI system or an agriculture smart system for semi-urban LGUs). By including a dimension of *innovation and experimentation*, the framework ensures LGUs are not just consumers of off-the-shelf solutions but can also contribute innovative approaches that others might adopt.

From Pilot LGU's perspective, the near-term tech priorities would be: expanding connectivity to 100% of barangays, maintaining and scaling the payment and command center systems, and integrating these into a unified service platform (perhaps a mobile app that combines city information, service requests, and payments). At the same time, building a robust data analytics capability in the city can turn the data from these systems into actionable insights (for example, analyzing what times most taxes are paid at kiosks to adjust staffing, or analyzing traffic CCTV feeds to redesign intersections). Each LGU will have different immediate tech needs (a coastal town might focus on environmental sensors, a dense city on transport and pollution monitoring), but our framework's modular approach allows for that, under an umbrella that all tech must serve the strategic outcomes and be supported by policy and institutional strength.

4.4. Proposed Smart City Framework for Philippine LGUs

The proposed Smart City Framework (see Figure 1) presents a policy-driven, people-centered, and technology-enabled structure for guiding the smart city development of local government units (LGUs) in the Philippines. Grounded in the empirical analysis and case study of Pilot LGU, this framework synthesizes the key insights and gaps identified in the study to offer a structured, adaptable model tailored to the Philippine LGU context.

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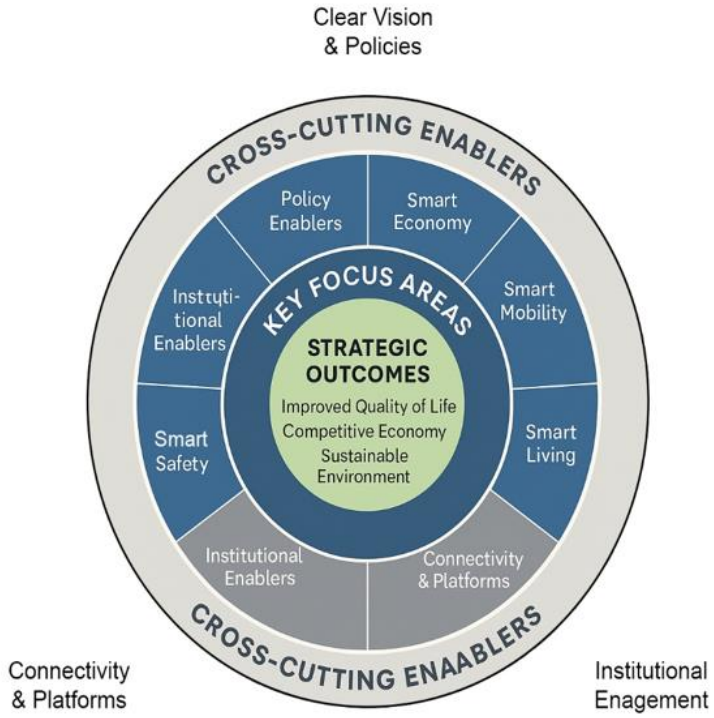

Figure 1.
Proposed Smart City Framework.

At the core of the framework are the Strategic Outcomes—namely, Improved Quality of Life, Competitive Economy, and Sustainable Environment. These outcomes reflect both global models such as the ASEAN Smart Cities Network and localized development priorities articulated in Philippine national and regional policy frameworks. The findings in Pilot LGU—particularly its investments in digital governance and safety—demonstrate incremental progress toward these outcomes but also highlight critical gaps, especially in innovation funding and system integration.

Surrounding the core are six Key Focus Areas, where smart initiatives are expected to produce tangible impacts:

1. Smart Governance – Pilot LGU's presence of an ICT Development Plan and its history of early e-governance innovations (e.g., computerized revenue collection, online tax payment kiosks) affirm this as a strong area. However, the absence of integrated digital service platforms signals a need for interoperability and further investment in digital platforms.
2. Smart Economy – Although Pilot LGU was not included in the DICT's "Digital Cities 2025," its initiatives on automation and process efficiency indicate movement toward economic digitalization. Yet, low R&D expenditure (zero in recent CMCI rankings) underscores the need for dedicated innovation funding and partnerships.
3. Smart Mobility – While the case findings did not indicate major advances in transport systems, plans for traffic monitoring through CCTVs and command centers suggest early-stage efforts. The framework provides pathways for expansion in this domain.
4. Smart Environment – Environmental monitoring and disaster preparedness were evident in the establishment of a DRRM command center. However, broader integration with sustainability tools such as energy management and climate data platforms remains an area for future development.

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5. Smart Living – The city's efforts in digitizing frontline services and deploying e-kiosks for citizen use align with this domain, especially in improving access to local government services. Additional initiatives in health and education technology could strengthen this dimension.
6. Smart Safety – This emerged as a clear strength in the case study, with real-time surveillance, traffic monitoring, and disaster response technologies already in place. These contribute to public safety and community resilience.

These focus areas are supported by Cross-Cutting Enablers**,** grouped into three categories:

1. Policy Enablers – The study highlights the importance of strategic planning, alignment with national standards (e.g., DOST, ISO 37122), and LGU-level ordinances. Pilot LGU's smart city vision reflects policy-level commitment, although gaps remain in budgeting and standards adoption.
2. Institutional Enablers – Leadership by the local executive and the presence of an ICT division were found to be essential. However, the findings also indicate a need to institutionalize stakeholder engagement, inter-agency coordination, and capacity-building systems to sustain and scale smart city efforts.
3. Technological Enablers – While initiatives such as free Wi-Fi, e-kiosks, and command centers exist, there remains a gap in establishing a unified digital infrastructure, including integrated platforms, data centers, and robust cybersecurity measures.

Finally, the outer feedback loop in the framework emphasizes adaptive governance and continuous improvement, informed by real-time data and performance indicators. As the study's findings suggest, smart city efforts must remain dynamic, with LGUs regularly assessing their performance (e.g., via CMCI or ISO metrics), identifying gaps (such as low uptake of digital services), and adapting accordingly through improved design, communication, or literacy efforts.

This framework, therefore, not only consolidates the lessons from the Pilot LGU case but also provides a scalable and flexible roadmap for other Philippine LGUs—regardless of size or urbanization level—to initiate, develop, and sustain their own smart city journeys.

Policy Recommendations

Based on the findings and the proposed Smart City Framework, the following policy recommendations are advanced to accelerate smart city development in Philippine LGUs:

4.5. For National Government Agencies

1. *Develop a National Smart Cities Roadmap*- A national vision with a 5–10 year horizon should be crafted, identifying agency roles (DICT, DOST, DILG, NEDA), milestones, and support mechanisms. A dedicated inter-agency Smart City Program Office should be created to provide coordination, technical support, and funding assistance. A Smart City Challenge Fund—similar to the Performance Challenge Fund—can incentivize aligned LGU initiatives.
2. *Institutionalize Standards and Metrics*- Mandate the use of internationally recognized frameworks (e.g., ISO 37122, ISO 37106) through DILG circulars, and integrate smart city readiness indicators into the Seal of Good Local Governance (SGLG). Training on digital governance should be mainstreamed through the DILG Local Government Academy.
3. *Enhance Data Interoperability*- DICT and the National Privacy Commission should release policies on secure and standardized data sharing. A national "Smart City Interoperability Framework" should guide system development across LGUs, ensuring compatibility and scalability.
4. *Facilitate Financing and PPPs*- The PPP Center should prepare templates and guidelines for common smart city projects (e.g., CCTV systems, smart mobility). Consider matching grants and low-interest loans through MDFO to help fund LGU initiatives, especially for less affluent municipalities.

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5. *Promote Regional and International Collaboration*- Nominate more cities to ASEAN Smart City Networks and support the formation of regional LGU smart city clusters. Organize an annual Smart Cities Summit to foster partnerships among LGUs, academia, and industry.

4.6. For Local Government Units (LGUs)

1. *Craft a Local Smart City Strategy*- LGUs should develop a formal strategy aligned with citizen needs and national frameworks like the DOST Smarter City domains. Strategies must be measurable, inclusive, and oriented toward improving quality of life, competitiveness, and sustainability.
2. *Establish Governance and Implementation Structures*- Form Smart City Councils composed of key departments and external advisors to ensure integration and sustainability. Designate an office or unit (e.g., ICT Division or Smart City Office) to lead implementation.
3. *Invest in Digital Talent and Capacity Building*- Allocate budget for upskilling staff and hiring technical specialists (e.g., data analysts, urban planners with ICT background). Collaborate with universities or tech professionals for technical mentoring and training.
4. *Strengthen Citizen and Stakeholder Engagement*- Conduct awareness drives, create feedback systems, and establish public-private collaboration platforms. Innovation challenges and forums with local business groups can co-create solutions and encourage adoption.
5. *Prioritize Quick Wins with Long-Term Scalability*- Implement pilot projects (e.g., free Wi-Fi, online services) that build momentum and confidence. Ensure all systems are designed for integration and long-term use.
6. *Ensure Sustainability and Evaluate Outcomes*- Maintain adequate post-project funding, measure impacts (e.g., service efficiency, public satisfaction), and adjust based on data. Sharing success stories and lessons learned (e.g., through ULAP or DOST platforms) will strengthen peer learning.

4.7. For Supporting Sectors (Academia, Industry, Civil Society)

1. Academia**:** Collaborate with LGUs on R&D, training, and technology development.
2. Industry**:** Align business services and CSR efforts with LGU digital needs.
3. Civil Society**:** Participate in co-creation, feedback, and digital inclusion efforts to ensure equitable transformation.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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