Cities' Dashboards as Civic Technology Platforms: A Scalable Model for Smart Cities through Integrated Governance in LUNGSOD, SMART METRO, and FASTRAC

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Abstract

The transition toward smart and sustainable cities in the Philippines requires both technological innovation and institutional coordination. This paper presents the integrated development and deployment of smart city platforms under three major initiatives—LUNGSOD, SMART METRO, and FASTRAC—led by the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (TCAGP) and supported by the Department of Science and Technology (DOST). LUNGSOD developed city-level dashboards in Iloilo City that enabled emergency response, citizen engagement, and spatial planning through a modular WebGIS and mobile application. SMART METRO scaled this concept to a regional level, building a multi-LGU data ecosystem anchored on geospatial databases, digital twins, and regional coordination dashboards across the Metro Iloilo–Guimaras Economic Development Council (MIGEDC), Zamboanga City, and Bayugan. FASTRAC, through LUNGSOD-FASTRAC, further enhanced these systems with scalable software engineering, security upgrades, and tiered deployment packages, addressing the challenge of translating R&D outputs into operational civic technology solutions. Across these initiatives, the evolution from cities' dashboards to interoperable civic tech platforms highlights the importance of user-centered design, open data architectures, and cross-jurisdictional coordination. The paper discusses key methodologies, pilot implementations, and governance models that enable these platforms to support responsive, data-driven governance. Lessons from these projects underscore the need for flexible procurement pathways, sustained capacity building, and alignment with national systems. Ultimately, the work demonstrates a replicable model for institutionalizing smart governance infrastructures at both city and regional levels, contributing to the Philippines' broader digital transformation goals.

1. Introduction

As the human population is exponentially growing and cities worldwide are expanding, governments are turning to digital tools to help them manage services and respond to the needs of their citizens. This digital shift is pushing local government units (LGU) to adopt systems that are not only based on data but also easy to use, adaptable, and able to show what's happening in different places. Smart city initiatives respond to this need by leveraging interconnected technologies to create responsive environments where real-time data can inform decision-making and support sustainable development goals. These initiatives primarily rely on information and communication technologies (ICTs), creating an intelligent network of interconnected objects and machines that transmit data via wireless technology and the cloud (Thales, n.d.). These smart cities use data and digital technologies to improve decision-making and enhance the quality of life. Citizens also engage in these smart city ecosystems in various ways through their smartphones and mobile devices (Thales, n.d.).

One of the core technologies enabling smart cities is the spatial digital twin (DT), which is a virtual representation that integrates static 3D models with dynamic data from sensors and historical records (Yan et al., 2019; Yu et al., 2017). While its definition continues to evolve, common elements include physical entities, their corresponding virtual counterpart models, data connections, and services (Tao et al., 2019). Unlike a digital shadow, which allows only one-way data flow from the physical to the digital, DTs support bi-directional interaction that enables virtual models to influence real-world operations (Kritzinger et al., 2018; Enders & Hoßbach, 2019). This two-way mapping allows for more accurate monitoring, analysis, and control of physical systems (Tao et al., 2019).

The concept of digital twins has expanded beyond aircraft and manufacturing to fields such as aerospace, healthcare, energy, and now, urban development (Talkhestani et al., 2018; Liu et al., 2020). In the smart city context, DTs are layered representations of urban data, such as terrain, buildings, infrastructure, mobility, and digital systems, processed within a virtual layer to simulate and optimize urban systems (White et al., 2020). With advancements in the 4th Industrial Revolution technologies, DTs can now drive applications by integrating vast datasets from various sensors and sources (Deren et al., 2021). Rather than being the end goal, it critically enables planning, management, and service delivery in smart cities. In such cities, problems can be identified and addressed in real time, offering solutions that improve the urban experience (Shepard, 2018).

As digital infrastructures evolve globally, the Philippines faces the dual challenge of catching up with rapid urbanization and technological disparity across regions. Smart city solutions offer a pathway to address complex governance and planning issues by embedding digital tools in LGU's everyday operations. Among these tools, cities' dashboards have emerged as foundational components—centralized platforms that visualize real-time data, enable service delivery monitoring, and support evidence-based decision-making (Barns, 2016). These dashboards integrate spatial information, citizen input, and administrative workflows to enhance transparency, responsiveness, and operational efficiency (Viale Pereira, 2022).

The Department of Science and Technology (DOST) recognizes the critical role of digital transformation in public service, particularly through its Smart Sustainable Communities and Cities Framework. This framework promotes open, integrated, collaborative, transferable, and human-centered technologies capable of enhancing resilience, mobility, and sustainability across both urban and rural areas (DOST, 2021). Within this policy context, the University of the Philippines Training Center for Applied Geodesy and Photogrammetry (TCAGP) has initiated a suite of projects that aims to forward technological solutions toward fully integrated platforms built on city and regional dashboards.

This paper presents the design strategies and system enhancements across three civic technology initiatives—LUNGSOD, SMART METRO, and FASTRAC—focusing on how dashboards can support sustainable civic infrastructures. It is guided by the question: How can modular, stakeholder-driven platforms scale from city-level to regional systems while staying responsive to local governance needs? We examine how co-developed dashboards and geospatial tools transition from pilot systems to institutionalized platforms, and how modular design, participatory methods, and tiered deployments support scalability, interoperability, and replicability. The paper situates these findings within broader debates on smart city governance and civic technology localization in emerging economies. The dashboard frameworks and data integration methods outlined in this paper can also inform future projects, for example, where high-resolution 3D urban data are essential for solar potential estimation and energy planning by LGUs.

2. The LUNGSOD and SMART METRO Projects

2.1 Background and Study Areas

Several international smart city initiatives offer instructive contrasts to civic technology approaches in decentralized, resource-constrained contexts. Singapore's Virtual Singapore exemplifies a centralized, top-down model—a $37 million 3D platform integrating transport, building, and climate data for planning (Stone, n.d.). Amsterdam combines top-down coordination with open data sharing across 32 departments, promoting inter-agency interoperability and civic engagement (The Smart City Journal, 2017). Hong Kong's Smart City Blueprint 2.0 focuses on mobile-first, citizen-centered urban services (Innovation and Technology Bureau, 2020). In contrast, the approach examined here is tailored to fragmented governance settings, where scalability, institutional alignment, and co-design with LGUs are critical.

The smart city model examined here bridges Planning Support Systems (PSS) and Socio-Technical Systems (STS) theory, offering a hybrid lens to understand civic technology institutionalization. PSS frames how spatial decision tools support planning via analytics and coordination (Geertman & Stillwell, 2012), but its real-world efficacy hinges on the social systems around it—an insight core to STS (Baxter & Sommerville, 2011). STS underscores that adoption depends on governance, engagement, and institutional readiness. The platform thus exemplifies a socio-technical planning support system: modular and geospatially enabled, yet participatory, embedded in workflows, and tailored to local constraints—enabling adaptability and sustainability in resource-limited contexts.

In response to DOST's thrusts for research and innovation for smart city solutions, the TCAGP has been undertaking several initiatives through directed research programs by the Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST –PCIEERD). Among these, the Project LUNGSOD (A Link-Up of Geomatics and Social Science Research for the Development of Smart Cities) in 2021-2023 and the ongoing SMART METRO (Modern Geospatial and Collaborative Solutions for the Development of Smart Regions) were conceptualized to show how digital twin technologies and integrated geospatial solutions can be applied to improve governance, public services, and citizen engagement.

The LUNGSOD project is primarily situated in Iloilo City in the Western Visayas region, as shown in Figure 1, and serves as both a pilot implementation site and a strategic innovation hub. Iloilo City is a rapidly developing, highly urbanized city known for its strong governance frameworks, active civil society, and progressive urban policies. It has been at the forefront of digital innovation and resilience planning, making it an ideal environment for localized smart city interventions (ISTAC, 2023). The city's diverse urban fabric of commercial centers, heritage zones, informal settlements, and peri-urban areas provides a valuable testing ground for the scalability and adaptability of smart technologies in real-world.

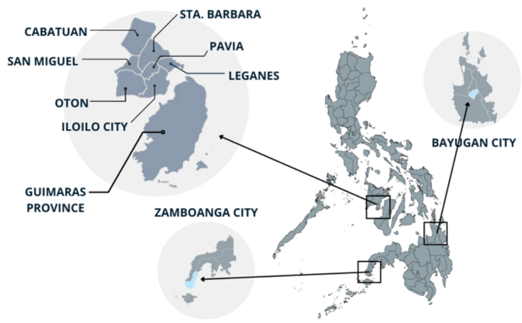

Figure 1. LUNGSOD and SMART METRO Study Sites.

The SMART METRO study area expands this study area to encompass the Metro Iloilo–Guimaras Economic Development Council (MIGEDC) region, which additionally includes the municipalities of Cabatuan, Oton, San Miguel, Pavia, Sta. Barbara, and Leganes in Iloilo Province, as well as the entire province of Guimaras in Western Visayas. The study area also extends to selected sites in Mindanao, particularly the Cities of Zamboanga City and Bayugan, to assess scalability and regional integration across diverse geographic contexts. This inter-LGU consortium exemplifies a regional model of collaboration, where challenges such as urban-rural migration, resource allocation, disaster risk reduction, and mobility require coordinated planning and data sharing. The region's mix of urban, peri-urban, and rural landscapes allows for testing system interoperability and shared digital services at scale, laying the groundwork for replicability in other parts of the Philippines.

2.2 LUNGSOD: Localized Urban Governance through Smart Data Systems

Urban governance in the Philippines faces enduring challenges in data-driven decision-making, service delivery, and spatial planning (UN-Habitat, 2023). Project LUNGSOD, implemented from February 2021 to April 2023, seeks to address these by integrating geomatics and social science approaches to develop responsive digital infrastructure for LGUs. This initiative positions digital transformation not merely as a technical upgrade but as a pathway to participatory, transparent, and adaptive governance rooted in real-world urban conditions.

This project serves as a foundational step toward building a localized smart city framework. The core objective is to establish a city-level system, the concept of which is shown in Figure 2, that supports decision-making and service coordination. This includes fostering the integration of spatial, statistical, and sensor-based information into platforms that city managers, policymakers, and residents can access and understand. Through this, LUNGSOD contributes to the institutionalization of smarter governance processes while encouraging a culture of data literacy and inter-office collaboration.

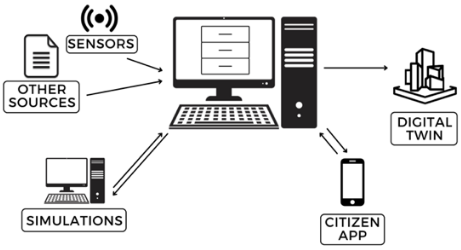

Figure 2. Concept of a data hub connecting sensors and systems to simulations and digital twin outputs

LUNGSOD's design centers on two components: City Command, a centralized Smart Command Center that provides geospatial support for city decision-making, and City Connect, a citizen engagement platform for online feedback, community programs, and mobile-based location tracking. Together, they enhance governance through improved data management, real-time monitoring, and participatory mechanisms addressing urban issues like safety, transport, and health. By focusing on the city scale, LUNGSOD redefines how LGUs collect and act on data for feedback, emergency response, and tourism. Emphasizing local context and community needs, the project advances a "smarter city" vision—one that learns, engages, and adapts in real time.

2.3 SMART METRO: Regional Integration through Geospatial Technologies

Moving beyond the city scale, SMART METRO introduces a regional paradigm of smart development grounded in the recognition that cities operate within broader systems. Anchored on the principles of shared data, collaborative planning, and aligned digital infrastructure, the project promotes interconnected growth by fostering geospatial intelligence and systems integration among neighboring municipalities. Unlike the city-centric LUNGSOD implementation, SMART METRO targets a wider scope through the development of comprehensive geospatial databases, spatial digital twins, and 3D regional models, while leveraging GeoAI for economic analysis, disaster response, and climate monitoring. Web-based coordination platforms and emergency dashboards are co-developed to enhance cross-jurisdictional governance and planning.

The project emphasizes institutional and technical capacity-building across members of the Metro Iloilo–Guimaras Economic Development Council (MIGEDC) and partner cities. Its methodology promotes multi-institutional collaboration and policy alignment to improve urban efficiency, rural inclusion, and inter-LGU cooperation. SMART METRO responds to core questions of how regional disparities can be addressed and how digital tools can foster spatial and institutional cohesion. Drawing from systems thinking and the concept of regional metabolism, the initiative captures not just flows of people and resources, but also intergovernmental dynamics, enabling a more adaptive and integrated model of regional governance.

3. Methodologies

3.1 Development of the LUNGSOD City Governance Dashboards

3.1.1 User-Centered Design through Stakeholder Coordination Workshops: LUNGSOD's design process was grounded in participatory systems thinking, with extensive engagement from users and stakeholders. The project began with a comprehensive diagnostic of Iloilo City's governance ecosystem to define dashboard requirements. Local conditions were assessed through continuous field consultations, document reviews, and key informant interviews with stakeholders from various LGU departments, including the Public Safety and Transportation Management Office (PSTMO), City Disaster Risk Reduction and Management Office (CDRRMO), Local Economic Development and Investment Promotion Office (LEDIPO), City Tourism Office (CTO), Information Technology (IT) Office, and City Planning and Development Office (CPDO).

The platform's development was shaped by systematic stakeholder engagement that surfaced operational gaps and directly informed both its architecture and functionality. A structured needs assessment—through interviews and focus group discussions with department heads, officials, and civil society—laid the foundation for this process. Formal Technical Working Groups (TWGs), created through executive orders and agreements, provided institutional support for iterative co-design. These engagements led to key design shifts: City Command's real-time alerts were adapted for mobile-first use and inter-agency coordination based on barangay feedback, while City Connect was introduced in response to calls for stronger citizen engagement. The process culminated in smart city policy workshops, where local leaders identified infrastructure and capacity gaps and began shaping a governance framework to sustain the platform. These participatory mechanisms enabled technical refinements and policy momentum unlikely to emerge from a purely top-down approach.

3.1.2 Backend Architecture and Interface Engineering: The City Command dashboard was built using a modular and scalable architecture. The backend leveraged the Django REST Framework for API development, PostgreSQL/PostGIS for spatial database management, and NGINX for server deployment. The frontend interface was developed in ReactJS and integrated with React Leaflet and TerriaJS for map rendering and interactivity. Multiple city-specific dashboards were developed for various city office modules: (1) Report an Issue Dashboard for the PSTMO; (2) Emergency Dashboard for the CDRRMO; (3) Tourism Dashboard for the CTO; and (4) Digital Twin for both the IT Office and CPDO.

The platform was designed with shapefile ingestion tools, which enabled users to upload barangay-level spatial data that could be immediately visualized and edited on the map. Administrative datasets were structured with metadata and linked to semantic tags for querying and visualization. Key features included form-based incident reporting, spatial filtering tools, interactive charts, and an alert system with configurable thresholds. Accessibility features and responsive design principles were applied to ensure usability across desktops and tablets. Figure 3 shows the interface layout for the WebGIS. In the left panel (A), searching, exploring, and upload functions are present. Panel (B) includes map navigation tools, while panel (C) contains project information. Finally, panel (D) contains map customization tools, and panel (E) is for rendering layers, including the basemap.

Figure 3. The interface of the LUNGSOD WebGIS platform (build version 2023.02)

3.1.2 Pilot Implementation and Operational Deployment in Iloilo City: The system was first deployed in pilot sites across seven barangays and multiple offices in Iloilo City, guided by a phased rollout strategy combining soft and hard launch activities. A Technical Working Group (TWG), created by executive order, coordinated the implementation, with designated point persons liaising between LGU offices and the project team. Deployment included server setup, user orientation, and provision of technical documentation. These structured engagements enabled the TWG to identify operational challenges and outline next steps post-launch. Emphasis was placed on the geodatabase and spatial digital twin, which were highlighted for their utility in planning and interdepartmental coordination. An open technical review further supported iterative refinements, while high-level consultation with the city mayor secured executive buy-in, plantilla creation, and local hardware procurement—critical steps toward institutional adoption and sustainability.

3.1.4 Performance Testing, Monitoring, and Adaptive Redesign: Post-deployment, the system entered an evaluation phase combining quantitative performance monitoring with qualitative user feedback. Automated logs of API calls, user sessions, and error reports were stored in a monitoring database, allowing the development team to detect system bottlenecks and implement backend optimizations using Django's caching framework and load balancing configurations. At the same time, co-design sessions with the Iloilo City TWG gathered insights on interface usability, data interpretation, and workflow integration. Feedback revealed issues such as form submission difficulties and map layer toggling errors, which were addressed through system patches. Resulting enhancements included customizable incident categories, a user notification system, improved data visualization, and strengthened security through HTTPS and PostgreSQL-level encryption—ensuring both functionality and security for long-term use.

Performance-wise, the system's mobile component recorded a peak installation rate in Iloilo City during its active deployment phase in August 2022, indicating user uptake under real-world conditions. Under the SMART METRO and FASTRAC projects, the same core dashboards—Report an Issue, Emergency, and Tourism—were deployed and tested in seven additional municipalities and one province comprising five more LGUs. Commitments have since been secured from three additional cities, another province, and an administrative region of five provinces, with active discussions ongoing in at least three more urban centers. While performance data from these newer sites are still forthcoming due to their early implementation stages, the expanding footprint underscores the model's institutional appeal, early scalability, and growing relevance across diverse local governance contexts.

3.2 Development of the SMART METRO Regional Dashboard System

3.2.1 Profiling and Regional Systems Framework: SMART METRO's initial phase focused on mapping the governance and data ecosystems of a broader multi-city region, using the Metro Iloilo–Guimaras Economic Development Council (MIGEDC) as the core study area, with Bayugan City and Zamboanga City included to test interoperability in diverse administrative contexts. This phase involved reviewing regional plans, conducting data infrastructure audits, and organizing consultations with LGUs, national agencies, and regional stakeholders to surface technical and institutional needs.

Three interoperable systems were conceptualized to form an integrated decision-support ecosystem, as shown in Figure 4, including the Regional Geodatabase, the Regional Metabolism Model, and the Regional Coordination Platform. The Geodatabase consolidates spatial and non-spatial data from LGUs, national agencies, Earth observation sources, and past DOST initiatives to enable spatial digital twins and thematic analytics. The Metabolism Model treats the region as a living system, using GeoAI to analyze flows of people, goods, and resources to inform resilience strategies and infrastructure planning. The Coordination Platform serves as the interface layer for cross-LGU data sharing and collaborative decision-making via dashboards and alert systems, supporting real-time policy alignment and regional governance.

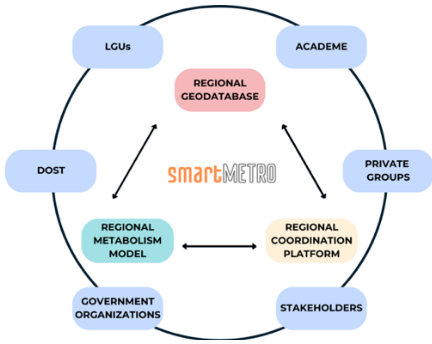

Figure 4. SMART METRO core regional systems structure

3.2.2 Embedding ICT and Tailoring Smart Solutions to Regional Needs: The SMART METRO methodology begins by embedding Information and Communication Technology (ICT) into region-wide systems while addressing the unique needs and capacities of each LGU within Metro Iloilo-Guimaras. The project aims to harmonize varying levels of "smartness" among member LGUs by identifying strengths and gaps in infrastructure, processes, and data readiness. Leveraging the Smart Region framework, the initiative formulates tailored "smart" approaches for each locality, including the development of a regional geospatial database that supports spatial planning and monitoring, applications of GeoAI for regional metabolism analysis, and a web-based regional coordination platform that enables cross-sectoral data sharing and governance.

Efforts to align technological components with LGU-specific contexts are guided by a design needs assessment and extensive field engagements. Each LGU's sectoral strengths—whether in tourism, agriculture, transportation, or disaster management—inform how systems are designed and embedded. The emphasis on fitting and matching ensures that digital tools are not one-size-fits-all but are localized and optimized to suit administrative workflows, resource availability, and policy mandates. This adaptive strategy builds trust among LGUs and improves the likelihood of long-term system adoption.

In future stages, ICT embedding will be strengthened and expanded through progressive rollouts of digital infrastructure, enhanced interconnectivity, and the introduction of analytics dashboards customized per LGU. The methodology will continuously evolve based on feedback loops, usability testing, and stakeholder participation. By balancing regional integration with local specificity, SMART METRO provides a scalable model for other emerging smart regions in the Philippines.

3.2.3 Prototyping and Simulation for Civic Platform Development: SMART METRO employs an iterative prototyping and simulation methodology to develop region-wide digital services. Key accomplishments include digitizing the region's geospatial profile, modeling sub-regions using Earth Observation data, and building web-based prototypes for climate monitoring, disaster reporting, and decision-support tools. These systems support applications in agriculture, disaster risk reduction, climate adaptation, mobility, and transportation. The project also prototypes a digital coordination tool to support regional information sharing, enabled by two interoperable platforms: Codex, a spatial digital twin for simulation and modeling, and Coordinate, a workflow management system for inter/intra-LGU collaboration. Coordinate features a ticketing and tracking system for streamlined document handling, status updates, and disaster-related documentation. Together, these platforms foster regional connectedness by unifying workflows into an integrated digital ecosystem.

The design of these civic platforms is grounded in scenario-based simulations that account for varying connectivity and resource availability across urban and rural contexts. Leveraging mobile GNSS, web GIS, and cloud-based interfaces, systems are tested for robustness, accessibility, and responsiveness under different conditions—serving both centralized command centers and decentralized community hubs. Key performance metrics include usability, data accuracy, and interoperability. The next phase involves scaling and refining these prototypes for multi-LGU deployment, incorporating real-time data inputs, and integrating feedback from simulations and stakeholder consultations into platform enhancements. This iterative process ensures that functionalities remain relevant and responsive, ultimately aiming to standardize the systems for broader adoption by other regional clusters in the Philippines and to position civic technology platforms as foundational tools for participatory, data-driven governance.

3.2.4 Leveraging Existing Technologies and Facilitating Technology Transfer: The SMART METRO methodology integrates past DOST-funded technologies as foundational components. The LUNGSOD Command and Connect systems, including the Digital Twin, serve as the core backbone. These tools are being adapted to support new use cases and additional LGUs beyond Iloilo City. The ALeRTO sensor network, initially deployed for early warning and disaster response, is also being considered for integration into the SMART METRO coordination platform through viable communication pathways. Likewise, DOST VI's Project Signal and the Intelligent Transpo initiative are being reviewed for regional traffic module integration. By consolidating these diverse technologies into a unified platform, SMART METRO builds an efficient coordination system connecting decision-makers, sensors, geodatabases, and service delivery nodes. This integrative approach maximizes the value of existing research investments while reducing the redundancy of new development efforts.

Beyond technology integration, SMART METRO emphasizes sustainability through comprehensive technology transfer mechanisms. The project will implement capacity-building programs, immersive mentoring, and policy crafting with LGU partners and stakeholders. Information, Education, and Communication (IEC) materials will be developed to support localized training. Through this multifaceted approach, SMART METRO ensures that civic technologies are not only adopted but embedded in institutional practice and community engagement.

4. Translating Smart City Systems into Scalable Solutions through FASTRAC

4.1 Rationale and Strategic Alignment

The FASTRAC Project (Funding Assistance for Spin-offs and Translation of Research in Advancing Commercialization) is a strategic initiative led by the DOST-PCIEERD designed to operationalize the translation of R&D outputs into scalable, commercially viable products. It specifically addresses the well-documented challenge of bridging the "valley of death" between research completion and technology adoption by offering structured support mechanisms for product enhancement, market validation, and early-stage commercialization. Through the FASTRAC: Enhancement and Market Validation of LUNGSOD project (LUNGSOD-FASTRAC), which commenced in October 2024 and is currently ongoing implementation in the TCAGP, FASTRAC supports the enhancement and deployment of a smart city system originally developed under LUNGSOD. FASTRAC's implementation aligns with the DOST Framework for Smart Sustainable Communities and Cities, which emphasizes open, integrated, transferable, collaborative, and human-centric systems.

The project's objective is not merely to produce a product that ends in the machines of the developers but to demonstrate how platform-based civic technology can be embedded into real-world governance structures, particularly in urban environments with varying levels of ICT infrastructure maturity. It aims to close the gap between R&D and adoption by ensuring that the platform is not only technically sound but also contextually adaptable, operationally sustainable, and institutionally integrated.

4.2 System Architecture, Development Workflow, and Deployment Strategy

LUNGSOD-FASTRAC adopts a modular and iterative systems engineering methodology guided by system enhancement, market validation, business model validation, and financial sustainability. Building upon the original development lifecycle of LUNGSOD—Design, Development, Testing, Iteration, and Deployment—the FASTRAC initiative introduces more formalized processes for scalability, integration, and sustainability, ensuring that the platform meets technical and governance-level requirements for adoption in LGUs' contexts. This structured methodology allows for responsive updates and tailored deployments, making the platform not only robust but also replicable across settings with different institutional capacities and development needs.

From a systems perspective, the backend architecture of the LUNGSOD platform was refactored into a modular monorepo thread, allowing multiple modules to operate independently while sharing common dependencies. This modularization supports both functionality updates and simplified code maintenance. Development was guided by updated UML system diagrams, feature tracking matrices, and integrated CI/CD workflows to optimize release cycles and sandbox testing. The architecture's interoperability—enabled through RESTful APIs—and the use of open-source geospatial components further support replication by allowing localized customization while retaining a consistent backend framework. These engineering choices, combined with governance-aligned deployment pathways, position the platform as a transferable and replicable model for other cities and municipalities seeking to implement similar civic technology systems.

LUNGSOD-FASTRAC proposes different tiers of system deployment based on LGU size, capacity, and intended use, packaged under a three-tier subscription mode, including LUNGSOD Starter, LUNGSOD Basic, and LUNGSOD Premium. These packages include varying levels of access to system components, such as the number of supported users, availability of modules, analytics capabilities, and branding options. Deployment services include technical documentation, cloud server installation and maintenance, training programs, and options for API integration and advanced analytics. While the base tier (Starter) is offered free of charge, pricing for the higher tiers is determined based on LGU size and feature complexity to ensure cost-effective scalability.

To support successful adoption and operational readiness, LGUs are expected to fulfill a standard set of requirements. These include forming a Technical Working Group (TWG), identifying a point person of contact, and submitting a Letter of Intent to formalize their commitment to adoption and deployment. Technical requirements include datasets of administrative boundaries, contact directories for key offices, and minimum hardware and connectivity specifications to support both dashboard and mobile components. These measures are designed to promote effective local ownership, streamline technical onboarding, and facilitate long-term system sustainability.

4.3 Platform Enhancements, Security Upgrades, and Pilot Implementation

The LUNGSOD-FASTRAC project has advanced the LUNGSOD system from a minimally viable prototype to a robust, production-ready smart city solution. Key enhancements were implemented across the system's backend logic, frontend interface, analytics layers, and cybersecurity infrastructure. The backend modules now support advanced spatial data functionalities such as custom basemap integration, layered data rendering, real-time geolocation filtering, and shapefile uploading. These upgrades allow for the ingestion and manipulation of heterogeneous spatial datasets, enabling use cases ranging from urban planning to hazard visualization and resource allocation.

On the frontend, the LUNGSOD Connect mobile application underwent interface optimization and was restructured to support user-type segmentation (e.g., residents vs. visitors), push notifications, and multilingual content rendering. These features enhance user personalization and accessibility, particularly in multilingual and demographically diverse LGUs. In the domain of cybersecurity and system compliance, the platform now incorporates two-factor authentication (2FA), session timeout management, OAuth-based third-party authentication, and end-to-end encryption protocols for data in transit and at rest. These upgrades were aligned with ISO/IEC 27001:2022 standards and prepared the system for eventual integration with national e-governance platforms and secure data exchange frameworks.

Pilot implementations were initiated in key LGUs, including Iligan City, Dipolog City, and MIGEDC LGUs, each deploying selected modules of the system based on local priorities—ranging from disaster preparedness and emergency reporting to citizen feedback integration. During these deployments, performance benchmarking, usage analytics, and stakeholder feedback were collected to inform ongoing system refinement. Dialogues have also been initiated with national agencies such as the MMDA and platforms like SafeTravelPH, exploring API-based interoperability and broader deployment across transport and urban management systems.

5. Evolving Cities' Dashboards into Scalable Civic Tech Platforms for Governance

The development and deployment of cities' dashboards, which are geospatially enabled interfaces that support data-driven urban governance, have become a central element of recent smart governance initiatives in the Philippines. The LUNGSOD and SMART METRO projects, complemented by the translational acceleration provided by FASTRAC, represent a progression in how these dashboards are conceptualized, implemented, and institutionalized. Table 1 shows how the stakeholders' engagement progressively influenced the system design and how these designs translated into governance outcomes. Initially focused on visualizing real-time data for city-level decision-making, these dashboards have evolved into more sophisticated civic technology (civic tech) platforms, initially defined as digital initiatives by civil society, private enterprises, and individual stakeholders, (Skaržauskienė & Mačiulienė, 2020) that not only display information but enable systems thinking citizen participation, and inter-governmental coordination.

Stakeholder Input	Tool/Feature Developed	Linked Capability	Observed Outcome/ Indicator
Barangay responders requested mobile-friendly interface with priority tagging for incidents	Real-time alerts in *City Command* with mobile-first UI and inter-agency tagging	Rapid incident reporting & coordination	Reduced response time
Community orgs and LGU offices raised gaps between citizen feedback and government response	*City Connect* module: citizen submission and tracking	Civic participation; data transparency	Increased uptake in citizen reports
Multi-LGU meetings highlighted data interoperability challenges	Regional geodatabase & shared dashboards	Cross-LGU collaboration	MIGEDC platform with inter-jurisdictional planning
LGUs requested varying levels of deployment and compliance with standards	Modular Starter/Basic/ Premium tiers	Scalable deployment; compliance	FASTRAC commercial pilot rollout (e.g., Iligan, Dipolog)

Table 1. Stakeholder-Informed Feature Development Across Projects and Their Governance Outcomes

The LUNGSOD project established the groundwork by designing a city governance dashboard system in Iloilo City, integrating modules for emergency reporting, citizen feedback, and situational monitoring. The dashboard was not merely a visualization layer but rather served as a digital infrastructure supporting participatory governance and responsive public services. SMART METRO expanded on this by reimagining the dashboard not only as a city-level tool but as a regional coordination platform capable of supporting multiple LGUs in areas such as disaster risk reduction, mobility planning, and regional economic monitoring. The project developed a federated architecture comprising a regional geodatabase, a metabolism model, and cross-jurisdictional policy dashboards. This marked a shift from single-system dashboards to integrated ecosystems of civic tech infrastructure. Importantly, this project illustrates that scalability requires interoperability, not just of data formats and APIs but of policies, institutional responsibilities, and planning cycles across LGUs.

The FASTRAC initiative further bridged the gap between innovation and adoption by focusing on software engineering maturity, cybersecurity readiness, and flexible deployment models. Enhancing the original LUNGSOD platform, LUNGSOD-FASTRAC introduced modular architecture, API-based integration, and secure authentication mechanisms aligned with global standards. It also operationalized a tiered deployment strategy for LGUs with varying levels of readiness, reinforcing the idea that civic tech platforms must be adaptable, configurable, and sustainable. Pilot implementations in Iligan, Dipolog, and MIGEDC LGUs validated that flexible packaging, supported by agency-to-agency procurement mechanisms, can facilitate adoption in real-world settings.

Across all three initiatives, a key insight is that cities' dashboards are no longer standalone visualization tools but are components of broader civic tech platforms designed to embed digital governance into the everyday operations of local and regional governments. They function at the intersection of data infrastructure, public administration, and community engagement. The integration of digital twins, GeoAI, mobile feedback tools, and workflow management systems extends their utility beyond decision support into foresight, resilience, and democratic participation. Table 2 summarizes the functionalities, target users, and scope of the platforms of the three projects.

Platform	Core Modules	Intended Users	Scope
Connect	Report an Issue, Emergency, Tourism	Citizens	City/Municipality
Command	Report an Issue, Emergency, Tourism	LGUs	City/Municipality
Regional Coordination Platform	Ticket Management, Threads, Announcements	LGUs	Regional
Digital Twin	Web Map Viewer	LGUs & Citizens	City/Regional

Table 2. Dashboard Variants by modules, users, and scope

Moving forward, there is a need to formalize a national roadmap that connects city-level innovation with regional-scale coordination. This need includes expanding LUNGSOD-FASTRAC's system packages to additional LGUs, fully deploying SMART METRO's analytics and coordination modules across the MIGEDC and partner cities, and aligning all efforts with national platforms such as eGovPH. The design of regional policy environments that support data sharing, cost pooling, and federated governance will be essential. Furthermore, continuous investment in local technical capacity and institutional partnerships with SUCs and national agencies will ensure the long-term vitality of these civic tech ecosystems.

6. Conclusions

The approach in this work demonstrates a replicable model of civic technology, evidenced by successful deployments across multiple cities and municipalities. Replicability stems not from tool transfer alone, but from a structured, modular design process, stakeholder co-development, and flexible deployment strategies. The evolution from LUNGSOD to SMART METRO and FASTRAC shows how core features can be scaled and localized without restarting development. Replication has been enabled through agency partnerships, inter-LGU collaboration, and policy-aligned implementation. Though adaptations may be needed for different workflows or data settings, the model's core principles, including modularity, responsiveness, and iterative co-design, provide a viable path for adoption in other regions.

While the projects demonstrated the potential of civic technology platforms to enhance local governance, it also surfaced key limitations and lessons. Data availability and quality varied significantly across LGUs, with some critical datasets either incomplete, outdated, or difficult to integrate into geospatial systems. This limits the functionality of certain modules that were developed. Capacity gaps in local technical teams also affected the consistent use and maintenance of the platform, particularly in areas lacking dedicated GIS or ICT personnel. Institutionally, sustaining stakeholder engagement proved challenging over time, especially when key government champions were reassigned or when feedback mechanisms were not formalized post-deployment. Additionally, transitioning from research to institutional adoption required navigating complex procurement and legal processes, underscoring the importance of long-term capacity building, structured governance models, and alignment with policy and procurement frameworks to ensure sustainability and scale.

Still, the experience of implementing and refining cities' dashboards through the three platforms provides critical insights into the evolution of civic technology for local governance in the Philippines. Beginning with city-level interventions focused on situational monitoring and community feedback and scaling toward regional systems that support inter-LGU coordination, these projects illustrate how civic tech platforms can bridge the gap between data availability and actionable governance.

LUNGSOD demonstrated that localized dashboards can improve service delivery and citizen engagement when properly integrated with city workflows. SMART METRO built on this by designing a regional framework that leverages data for planning and coordination across jurisdictions, while FASTRAC ensured that the platforms emerging from these R&D efforts are technically robust, institutionally adaptable, and commercially viable, which brings them closer to widespread deployment and long-term sustainability. A key convergence point of these technologies is the creation of an integrative, interoperable, and cross-sectoral platform for data-driven decision-making and evidence-based development planning that extends beyond local governance. These integrated systems can be seamlessly linked into national digital ecosystems or platforms developed by agencies such as DOST, enabling broader scalability, alignment with parallel initiatives, and the ability to support expanded use cases across varying governance levels. Complementing these civic technology efforts, related research are supported, such as one exploring the use of 3D geospatial data for renewable energy estimation in urban environments. This work similarly leverages spatial data integration and digital modeling, highlighting the versatility of geospatial technologies beyond governance and into energy resilience. Together, these initiatives reflect the growing importance of 3D-enabled systems in shaping smarter, more sustainable cities.

Collectively, these initiatives show that smart cities for governance are not just a technical aspiration but a multi-layered institutional transformation. The progression from dashboard to platform, from visualization to intelligence, and from pilot to policy alignment marks a promising future for digital governance. By continuing to invest in adaptable and scalable civic tech platforms, the Philippines can lead the way in building resilient, data-driven, and participatory local governments.

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