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Knowledge Sharing Program

Enhancing Development Strategies for Strengthening Smart City Organization and Technology in Zagreb, Croatia

Croatia

2023/24 KSP POLICY BRIEF

Presented by the MOEF, Republic of Korea

Ministry of Economy and Finance
KDI Korea Development Institute
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Project Title: Enhancing Development Strategies for Strengthening Smart City Organization and Technology in Zagreb, Croatia

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In Cooperation with
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Preface

In today's globalized world, knowledge sharing among nations is pivotal for addressing development challenges and promoting economic and social progress. The post-COVID-19 era has further highlighted the critical role of knowledge in tackling global issues like climate change, supply chain disruptions, and economic instability.

Korea's own development journey, driven by knowledge and technology transfer, provides a valuable model for other countries. The Knowledge Sharing Program (KSP), introduced by Korea's Ministry of Economy and Finance (MOEF) in 2004, has played a crucial role in supporting socio-economic development in partner countries. The Korea Development Institute (KDI), Korea's leading think tank, has partnered with over 100 foreign countries through KSP, offering solutions in various fields, including digital and green economy.

The City of Zagreb expressed a desire to establish a "Smart City Development Strategy Improvement Plan" aligned with its new urban development direction. Through the Knowledge Sharing Program (KSP), discussions were held to improve the overall smart city development strategy, along with establishing a governance system for efficient implementation and devising specific action plans for expanding smart technologies.

I extend my appreciation to all involved in this project, from the City of Zagreb to the KSP research team, and the contributors. I believe that KSP will further enhance mutual learning and economic cooperation between Croatia and Korea, contributing to the sustainable development of both countries.

Oh, Kyun
President
Seoul Institute

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Summary

This project aims to improve and establish implementation strategies for Zagreb's smart city initiative. To achieve this, we will evaluate the current state and effectiveness of Zagreb's smart city strategy. Through this analysis and by examining case studies of smart cities in prominent Korean and European cities, we will propose improvements to Zagreb's development strategy, ensuring alignment with the Development plan of the City of Zagreb for the period until the end of 2027. Additionally, we will develop a smart city service roadmap and proceed with the project by selecting a smart district, proposing an integrated platform, and presenting a governance framework.

- **Establishment of Smart City Service Implementation Plan.** To achieve the goals of the Development plan of the City of Zagreb, 81 smart city services were derived. Based on current urban conditions and smart city status, 25 core services were identified for initial implementation, including 13 existing and 12 new services. Implementing these services is expected to increase the quality of life of Zagreb citizens.

- **Establishing ICT Infrastructure for Smart City Services.** A plan for building ICT infrastructure was proposed to support smart city services. An integrated operation plan for the smart city, an integrated platform introduction plan, and an integrated control center introduction plan were proposed to ensure systematic and efficient provision and operation of smart city services. The estimated cost for establishing an integrated control center is EUR 5,829,900. If an integrated platform is established, data collection, processing, and provision are expected to be streamlined, allowing real-time data to create conditions for better smart city services.

- **Introduction to Smart District.** The Eugen Kvaternik Square area was chosen as a pilot target area. Services suitable for regional characteristics and ICT construction plans were proposed for implementation. The estimated cost for building services in smart districts is EUR 3,944,400. This project aims to provide citizens with firsthand smart city experience, fostering closer engagement with smart city services and ICT.

- **Suggestion for Zagreb Smart City Governance.** A plan to strengthen Zagreb Smart City governance was proposed. Zagreb City Administration would form a committee to oversee smart city services and establish a system to enhance communication and coordination in order to promote collaboration between departments. Conditions to encourage active participation from both public and private companies were also recommended. Effective governance is expected to streamline smart city service provision, ultimately increasing the citizens' quality of daily life.

1. Introduction

In 2019, the Capital city of the Republic of Croatia, Zagreb established the ZAGREB SMART CITY FRAMEWORK STRATEGY vision up to 2030 to advance sustainable urban development and enhance its tourism sector. This strategy includes six development areas and 27 implementation goals. It also established the Zagreb Smart City Hub platform to gather public data and share information with citizens. The six development areas consist of Digital infrastructure, Efficient, transparent and smart city administration, Smart energy and utility services management, Education, Economy and Sustainable urban mobility. Various projects are underway, including the expansion of 5G infrastructure and the introduction of smart services such as parking and vehicle sharing. (As of 2023, 99 projects are underway.)

In line with the EU's and Croatia's development path, the City of Zagreb has defined urban development directions, such as climate change response, energy efficiency, and carbon neutrality, resulting in the formulation of the Development plan of the City of Zagreb. Given these developments and changes in urban conditions, there is a need to update the ZAGREB SMART CITY FRAMEWORK STRATEGY.

This project aims to enhance and establish implementation strategies for Zagreb's smart city initiative. To achieve this, we will assess the current state and effectiveness of Zagreb's smart city strategy. By analyzing case studies of leading smart cities in Korea and Europe, the KSP project proposes improvements to the City's development strategy, ensuring alignment with its Development plan of the City of Zagreb. Furthermore, the project will propose technological applications and a governance framework to facilitate efficient implementation.

To ensure the success of the project, we first establish overarching goals, such as achieving a green and resilient economy. Next, we categorize smart city services and identify policy objectives requiring the implementation of these services. Through case studies, we then determine which smart city services align with these objectives. Next, we conduct a gap analysis to understand the current state of smart city services, urban conditions, and gather insights from stakeholders, experts, and citizens. Finally, we develop a smart city service roadmap and proceed with the project by selecting a smart district, proposing an integrated platform, and presenting a comprehensive governance framework.

2. Diagnosis of Zagreb Smart City

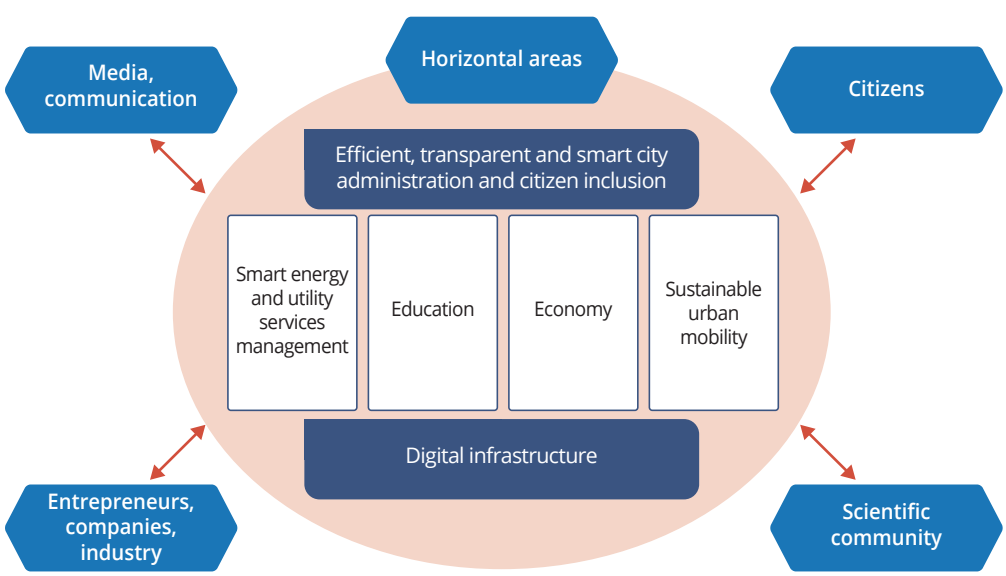
2.1. Status of Zagreb Smart City

2.1.1. Smart City Services

In 2019, Zagreb established a ZAGREB SMART CITY FRAMEWORK STRATEGY to guide its sustainable urban development efforts. This Framework Strategy serves as a starting point, offering open, flexible and clear guidelines for the city's future development. It supports specific project solutions at the field level.

To implement measures and projects effectively, it is necessary to draft a separate action plan or other implementation document. This document will provide detailed information about specific technological solutions and ranges (scope of implementation) for each strategic area. This data will form the basis for estimating the amounts and sources of financial assets needed for each implementation year, which must be coordinated with the City of Zagreb's budget.

Figure 1.
Zagreb Smart City Configuration Diagram



Source: Zagreb City (2019).

The strategic plan for smart city development in Zagreb focuses on six areas: digital infrastructure, sustainable transportation, sustainable economy, smart administration, digital education, smart energy. Within these areas, 27 implementation goals have been

established. Zagreb currently offers 99 smart city services (projects/activities), which are continuously provided to citizens. These include 5 digital infrastructure services, 50 smart governance services, 12 smart energy services, 1 smart education service, 8 economic services, and 24 urban mobility services. These services are shared with citizens through the smart city website, detailing their content and progress.

Within the Digital Infrastructure, five services are currently available. Data collection and coverage are crucial aspects of this sector. According to relevant websites and interviews with Zagreb officials, it was found that data collection pertaining to digital infrastructure encompasses the entire Zagreb area. However, the prevailing data collection methodology is predominantly manual, resulting in inconsistent and non-real-time data acquisition. Nonetheless, ongoing efforts are underway to expand basic infrastructure, including the installation of fiber optic cables.

In the Smart City Administration of Zagreb, a range of information is gathered and disseminated to citizens. Many services related to E-Government, represented by E-Zagreb, are being offered. Administrative tasks such as applications and permits, opinion gathering, and newborn support are provided through E-Zagreb. This system enables citizens to conveniently access these services. Additionally, Zagreb is establishing a foundation for urban data collection and provision through its GeoPortal, making various city-collected data available. Most services are accessible throughout Zagreb, indicating a good spatial range of services. However, it has been noted that data collection is often irregular, hindering real-time information provision. Furthermore, the means of information provision are mostly limited to web pages or web GIS, suggesting a need for more diverse channels to disseminate information.

In Smart Energy and Utility Services Management, various services are being implemented to address climate change. These initiatives focus on improving energy consumption efficiency and increasing the use of renewable energy. Among these initiatives are automatic meter reading for water meters, gas network management services, smart public lighting, and energy innovation services for public buildings. Additionally, smart city services that encourage the use of renewable energy sources like solar energy and rainwater systems are being introduced. However, the scope of these services and projects is limited, often targeting specific buildings or districts rather than city-wide implementation. This concentration may be attributed to the nature of pilot projects, which often target specific areas. Expanding services city-wide after the pilot phase is crucial. Moreover, most data collection is conducted manually and irregularly, emphasizing the need for IoT sensors and similar technologies to facilitate real-time data collection and provision, thereby enhancing service effectiveness.

In the Smart Education and Economy Domains, projects and services such as smart schools and startup support are being implemented. These services are primarily

offered as pilot projects targeting specific citizens rather than being accessible citywide, making the number of services relatively limited compared to other sectors. Furthermore, it was noted that data collection is mostly done manually and irregularly, indicating a need for improvement in this area for future service enhancement.

In Sustainable Urban Mobility, initiatives are underway to promote eco-friendly transportation and provide transportation information services. However, these services often lack real-time data collection and are primarily offered as pilot projects. Many of these projects heavily emphasize infrastructure development rather than comprehensive smart city initiatives. To enhance the effectiveness of the service, real-time data collection and comprehensive information provision are essential.

2.1.2. Zagreb ICT Infrastructure

Zagreb Holding

Established in 2006 in accordance with company law, Zagreb Holding is solely a wholly-owned City trading company of the City of Zagreb. Operating in line with the principles of public service, its primary focus is providing services that serve the general economic (public) interest. The group collectively provides more than 50 diverse services categorized into five business areas (activities), with 20 of these services classified as serving the general economic interest.

Zagreb Digital City

Zagreb Digital City, one of the Zagreb holding branches,was established in 2006 and is responsible for managing, building, and maintaining Zagreb's IT communication systems and shared infrastructure. It maintains and manages the city's underground communication system (DRK) and other shared infrastructure facilities.

Zagreb Digital City has installed a triple-layer structure of optical cables throughout the city. This infrastructure covered 85% of the city, with the remaining 15% utilizing wireless networks for connectivity.

Waste Management

In Zagreb, a door-to-door waste collection system is available. General waste (mixed waste) must be disposed of using pay-per-bag services, while recyclable waste (plastic, metal, etc.) can be disposed of free of charge. Zagreb operates an integrated management system for waste disposal.

ZagrebParking

The city of Zagreb is divided into three parking zones: red, yellow, and green, with red being the most expensive. There are a total of 83,000 parking spaces operating within the city center.

Figure 2.
ZagrebParking Enforcement Vehicle

ZET (Zagreb Electric Tram)

In Zagreb, ZET (Zagreb Electric Tram) operates the public transportation system that includes trams, buses, and a cable car. A communication network relays location and status data from trams or buses to a central hub. Information provided to public transportation users includes real-time arrival information, real-time connection information, bus route details, and bus operation plans. Information delivery methods include BIT, on-board terminals, mobile integration with Google Maps, and text and voice delivery methods. Additionally, in the event of accidents or other incidents, passengers receive notifications through message alerts.

Figure 3.
ZET Operation Center

Zagreb City Offices

The Traffic Operations Center serves as a central hub for collecting data and optimizing traffic signal operations based on prevailing traffic conditions. To calculate traffic volume, CCTV cameras are strategically placed to monitor and adjust signal operations in real-time. Additionally, these cameras enable the detection of pedestrians, motorcycles by lane, and cars in all directions, providing valuable insights into traffic patterns. However, it is important to note that this collected information is not readily accessible on platforms such as Google. Zagreb boasts an extensive network of approximately 700 CCTV cameras, primarily mounted on traffic lights for operational purposes.

GIS maps serve as a central repository for managing the locations of public lighting. There are plans to install between 500 and 1,000 remote modules. Currently, while the installation of LED lighting is feasible, adding additional sensors poses a challenge due to the involvement of other departments and their respective areas. Consequently, there are no plans to install various IoT devices on a single pole, as it would necessitate coordination and decision-making across multiple departments.

The Sector for Utility Service and Traffic Center operates a total of 570 CCTV cameras, including 200 4k CCTV cameras. The Video Management System (VMS) used is King ICT, a local Croatian company. The types of CCTV cameras in operation are Hikvision (185), Axis (185), and Bosch analog cameras (200).

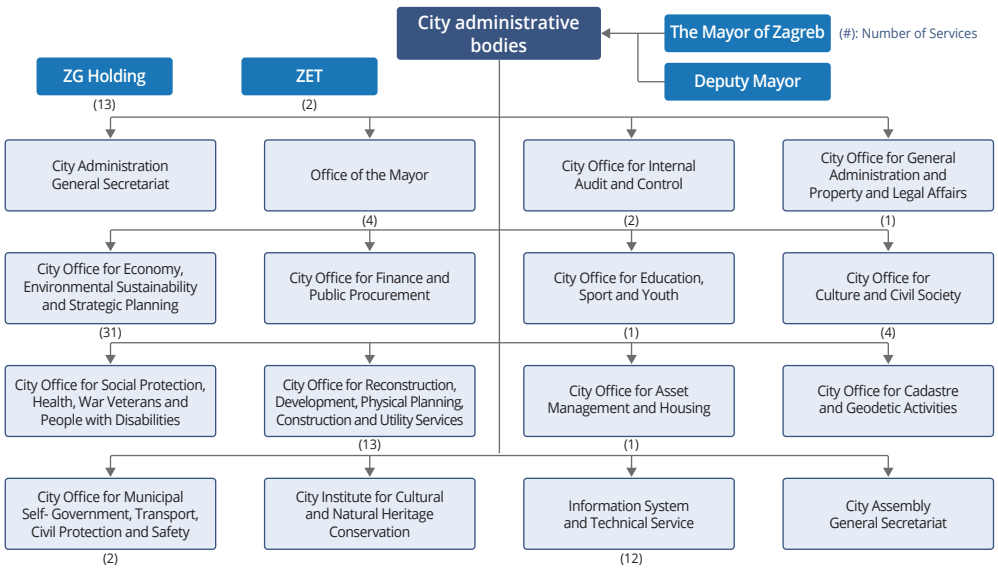
A Geoportal can be understood as a platform designed to streamline the management of metadata, mapping processes, geocoding functions, data downloading, and the dissemination of widely distributed geographic information. It aims to address compatibility issues in geographic information systems by providing access to geospatial information through two primary components.

2.1.3. City Aministration

The organizational structure of Zagreb is as follows. Zagreb's organizational framework is characterized by parallel structures for each City Office. Although the influence of Offices may vary, they generally hold equivalent positions. Presently, Zagreb is exploring and implementing smart city services at the City Office level. The following diagram illustrates the current count of smart city services within each City Office in Zagreb.

Nominal responsibility for smart city services in Zagreb lies with the City Office for Economy, Environmental Sustainability, and Strategic Planning. This City Office is tasked with coordination of smart city development. However, it appears that this City Office is only involved in planning and assessing the status of these services. The current system allows each City Office to independently research and offer services, resulting in a fragmented approach.

Figure 4.
Status of Smart City Services per City Office



2.1.4. Implications

Zagreb's smart city service evaluation revealed a persistent effort to expand services for citizens' convenience. Across 6 sectors, 99 services are offered.

Most services aim to reach all citizens in terms of service coverage. However, exploring more accessible options is crucial, as the majority of services are provided through web pages or web GIS.

The most significant challenge identified in Zagreb's Smart City services is the method of data collection and provision. Due to the manual collection of most data, real-time data utilization for information provision is limited. This results in relatively lower service quality.

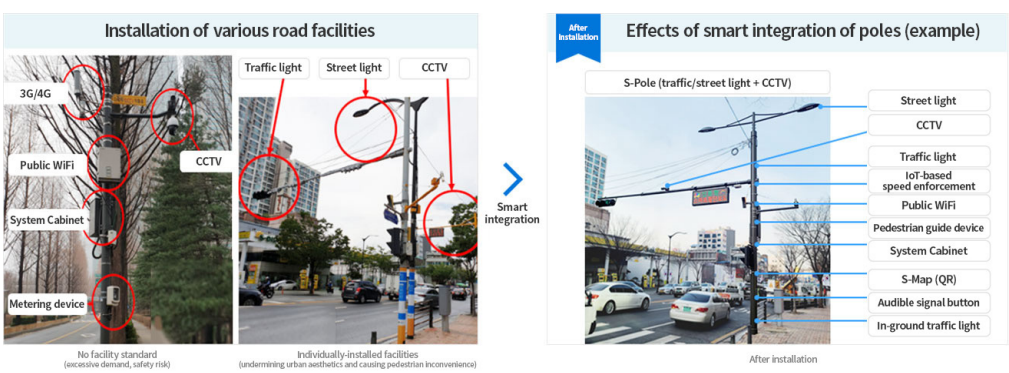
The most significant issue facing smart city governance in Zagreb is the lack of a central authority empowered to plan, establish, and implement these services. Given the diverse range of smart city services, redundancy and inter-departmental cooperation are essential. However, Zagreb currently lacks a committee or focal point capable of assuming this role. Consequently, each City Office focuses solely on exploring and implementing its own smart city services, leading to inefficiencies and limitations in service provision. Furthermore, inadequate inter-departmental collaboration limits the identification and provision of services desired by citizens.

2.2. Case Study in Smart City

2.2.1. Smart City Services

In its vision for the future, Seoul aspires to become a leading smart standard city by harnessing digital transformation. The city's initiative aims to enhance urban competitiveness through the establishment of an innovative foundation for smart city transformation, leveraging advanced technologies. This vision encompasses transitioning to a people-centric intelligent information society and realizing an inclusive smart city. Additionally, Seoul emphasizes the provision of advanced technology-integrated citizen perception services as a means to address complex and diverse urban challenges. The detailed tasks by sector are World's Best Smart City Infrastructure Expansion, Accelerating Digital-Based Administrative Innovation, Establishment of an Open Big Data City, Expansion of Non-face-to-face Services, Realization of a Smart Inclusive City, Realization of a Cyber Safe City, Establishing Smart Mobility Infrastructure, Providing Safe and Secure Urban Services, Support for Activation of Digital Economy.

Figure 5.
Smart Poles (Seoul Case)



Source: Seoul Metropolitan Government, "IoT, Communications, and Security," accessed October 21, 2024, https://english.seoul.go.kr/policy/smart-city/iot-communications-security.

Prague's smart city identity can be summarized by five key terms: ecological, innovative, digital and open, friendly and motivating, safe and resilient. The aim is sustainable growth and high quality of life: Mobility of the Future, Waste-free City, Smart Buildings and Energy, Attractive Tourism, People and Urban Environment, and Data Platform(Golemio).

In Vienna, the vision is a city that maintains a high-quality life and does not negatively affect the environment and future generations. The goal is to maximize resource conservation while providing a high-quality life to residents through social and technological innovation in all fields, and to reduce greenhouse gas emissions by 55% by 2030, achieving Net-Zero by 2040. The detailed tasks by sector are Energy Supply, Economy and Employment, Zero Waste and Circular Economy, Participation, Engagement and Culture, Mobility and Transport, Adapting to Climate Change, Health and Social Inclusion, Digitalization, Buildings, Urban Ecology, Environment and Water, Education, Science and Research.

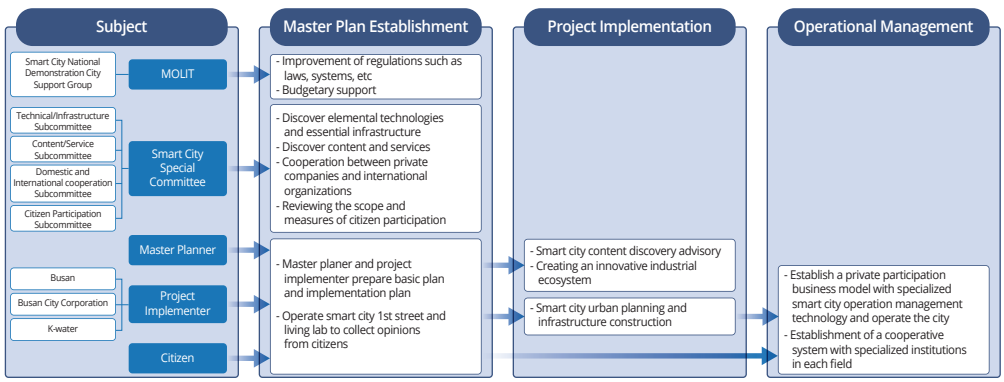
Figure 6.
WienMobil Mobility Points (Vienna Case)

Source: Smarty City Vienna (2022).

2.2.2. Smart City Governance

In Busan, Korea, several governance entities including the Ministry of Land, Infrastructure and Transport, the Smart City Special Committee, Master Planner, implementers, and citizens are all involved in smart city projects. The project progresses through the stages of master planning, implementation, and operation and management. The participating entities in each stage are as shown in the diagram below.

Figure 7.
Busan Governance

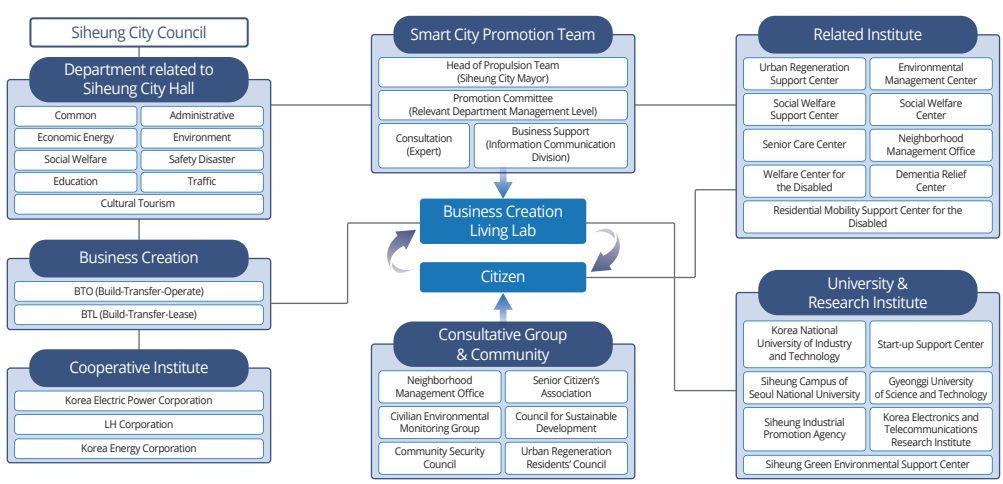


Source: Ministry of Land, Infrastructure and Transport (MOLIT), Republic of Korea (2018).

In this context, Smart City 1st Street is a distinctive citizen participation platform open to citizens and private experts from the urban planning stage to the development process. Meanwhile, Living Labs are innovative communities where citizens take the lead in innovative activities to address various urban issues directly.

Siheung, Korea, a dedicated smart city task force has been established, comprising a steering committee and a promotion committee at its core. This task force spearheads the smart city initiative, collaborating closely with the Siheung City Council and relevant departments of Siheung City Hall. Additionally, the Business Creation Living Lab involves not only citizens but also universities and various institutions, fostering collaborative participation in the project.

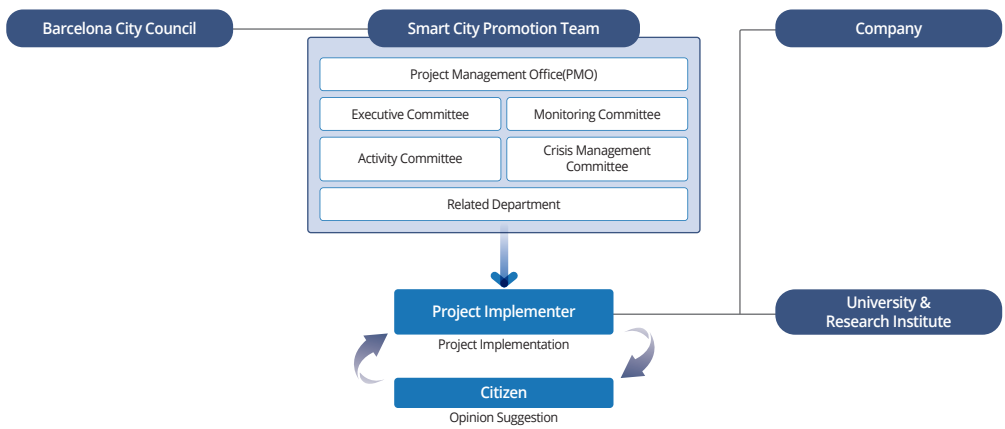
Figure 8.
Siheung Governance



Source: Siheung City (2018).

In the case of Barcelona, a smart city task force has been formed with a project management office (PMO) and four committees at its core. The project is driven through project implementers, actively incorporating citizens' opinions throughout the process.

Figure 9.
Barcelona Governance



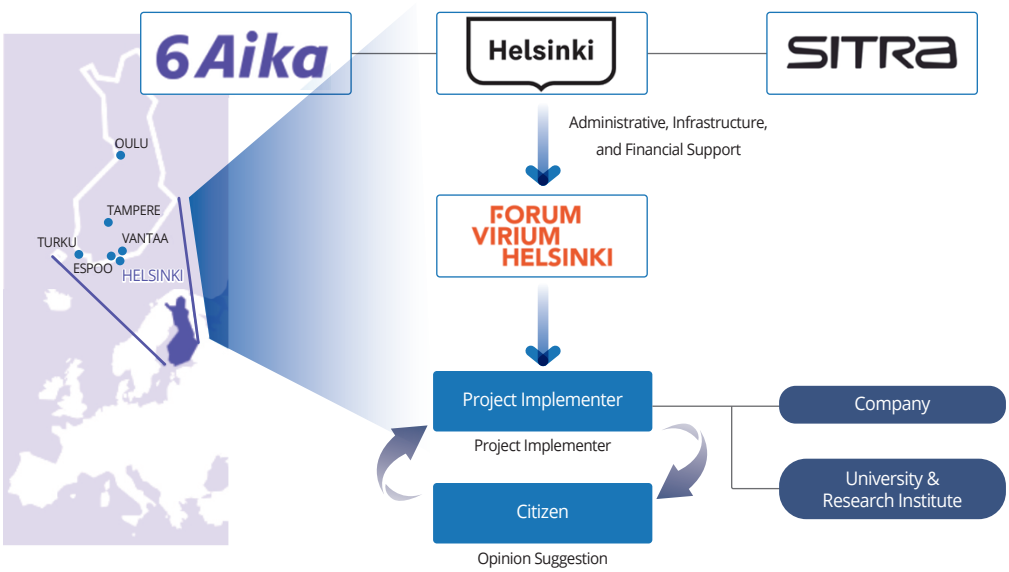
Source: Ferrer, J.R. (2017).

The committees consist of the Execution, Monitoring, Operations, and Crisis Management Committees, each with specific roles alongside the PMO.

- PMO: Oversees and coordinates all aspects and stakeholders of smart city-related projects.
- Execution Committee: Reviews progress reports on a quarterly basis via the Smart Barcelona Project Management Dashboard.
- Monitoring Committee: Reviews progress reports on a monthly basis via the Smart Barcelona Project Management Dashboard.
- Operations Committee: Supervises project status weekly and monitors progress.
- Crisis Management Committee: Analyzes crisis situations arising from project issues and formulates plans for crisis resolution.

In Helsinki, the initiative is led by Forum Virium Helsinki (FVH), supported by 6Aika, the City of Helsinki, and SITRA(Finnish: Suomen itsenäisyyden juhlarahasto, The Finnish Innovation Fund). Projects are driven by project implementers, actively incorporating citizens' opinions throughout the process.

Figure 10.
Helsinki Governance



Source: Seoul Digital Foundation (2021).

In Helsinki, FVH serves as a central institution, fostering collaboration between the public and private sectors. It was established to promote digital innovation and development. 6Aika, a union of six major Finnish cities, focuses on addressing common urban issues. Additionally, SITRA, a public foundation, plays a role in cultivating innovation within Finland by creating innovation funds.

3. Policy Implications

3.1. Identifying Zagreb Smart City Services

Through case studies, smart city services needed for Zagreb were identified. The identified services were then matched with the objectives outlined in Development Plan of the City of Zagreb.

Table 1.
Smart City Services for the Green and Resilient Economy Sector

Goal	Objective	Code	Smart City Service
Green and Resilient Economy	1. Development of a Sustainable and Competitive Economy	EC1	Online Shopping Mall Operational Services
		EC2	Innovation Startup Support Service
	2. Strengthening the Growth and Competitiveness of SMEs (small and Medium-sized Enterprises) and Crafts	-	-
	3. Strengthening the Labor Market	-	-
	4. Support Sustainable, Resilient, and Competitive Tourism	C1	Beacon Information System for Tourist Destination
		C2	Collection and Guidance of Information on Major Tourist Destination, Cultural Content, Etc.
		C3	IoT-based Cultural Property Management
	5. Support Sustainable Development of Agricultural Production and Forestry	-	-

Table 2.
Smart City Services for Social Equality, Quality, and Accessible Social Services Sector

Goal	Objective	Code	Smart City Service
Smart City Services for Social Equality, Quality, and Accessible Social Services	6. Improving the Quality and Availability of Education	ED1	Integrated Future Library System
		ED2	School Administrative and Educational Process Computerization
	7. Improving the Quality and Availability of Health and Social Services and Encouraging a Healthy and Active Lifestyle	W1	Personalized Healthcare Service
		W2	Smart Physician Service
		W3	Medical Location Information Service
		W4	Healthcare Services for Senior Citizens Living Alone
		W5	Emergency Safety Notification Service for People with Severe Disability

Table 2. (Continued)

Goal	Objective	Code	Smart City Service
	-	W6	Emergency Patient Management System
	8. Empowerment of Culture and Creativity	-	-
	9. Development of an Efficient City Management System with Open Opportunities for Citizen Participation	G1	Data Collection and Delivery Service
		G2	Application Processing and Public-Related Documentation Service
		G3	Administrative Convenience Improvement Service Using ICT
		G4	Civil Opinion and Reporting Service
		G5	Utility or Tax Payment Service
		G6	Provision of Civil Service
	10. Improvement of Urban Security in the City of Zagreb	W7	Reassuring Return Service
		S1	Incident and Accident Detection System
		S2	Collection of Floating Population Information
		S3	Smart Security Lights in Alleyway
		S4	IoT Beacon Control Center
		S5	CCTV Service for Crime Prevention
		S6	Customized Fire Safety Net Construction for Vulnerable Individual
		S7	Smart Evacuation Agent
		S8	Facility Monitoring System
		S9	Underground Facility Monitoring System
		S10	Real-time Fire Facility Management System
		S11	Urban Water Disaster Integrated Management System
		S12	Fire Evolution Support System
		S13	ICT-based Integrated Disaster Management System

Table 3.
Smart City Services for Effective and Sustainable Management of Spatial and Natural Resources Sector

Goal	Objective	Code	Smart City Service
Effective and Sustainable Management of Spatial and Natural Resources	11. Improvement of the Property Management System and City Spatial Planning	-	-
	12. Environmental and Nature Protection	-	-
	13. Improvement of Community Infrastructure	-	-

Table 4.
Smart City Services for Green Transition and Digital Transformation sector

Goal	Objective	Code	Smart City Service
Green Transition and Digital Transformation	14. Encouragement of Energy Transition	E1	Smart Grid Energy Management
		E2	Urban Energy Monitoring
		E3	Solar Power Plant
		E4	Zero Energy Complex
		E5	Zero Energy Building
		E6	Smart Water Treatment
		E7	Collection and Management of City Gas Data
		E8	Smart Water Metering (Remote Instructions)
		E9	City Gas Piping Detection System
		E10	Water Pipe Detection System
		E11	Integrated Energy Information Platform
	15. Clean and Sustainable Traffic	T1	Integrated Mobility Service (MaaS)
		T2	Provision of Public Transportation Information
		T3	Generation and Maintenance of Public Transportation Information
		T4	Enhancement of Public Transportation Facilities Using ICT
		T5	Demand-Responsive Mobility Service
		T6	Collection and Provision of Traffic Information
		T7	Traffic Monitoring System

Table 4. (Continued)

Goal	Objective	Code	Smart City Service
	15. Clean and Sustainable Traffic	T8	Advanced Traffic Operations Using ICT
		T9	Identification of Hazardous Road Section and Area
		T10	Management of Unforeseen Situation
		T11	Smart Signal
		T12	Emergency Vehicle Priority Signal System
		T13	Unmanned Enforcement of Illegal Parking
		T14	Smart Parking Service
		T15	Autonomous Mobility Service
		T16	Car-sharing Service
		T17	Public Bicycle Rental and Location Information Service
		T18	Personal Mobility Service
		T19	Traffic Big Data Integrated Management System
		T20	Smart Crosswalk
		T21	Smart Road Surface Information Sign
		T22	School Zone Safety System
		T23	Artificial Intelligence Pedestrian Alert
		T24	Smart Cycling
		T25	Acquisition and Utilization System for Bicycle Information
		T26	Electric Mobility Service (Electric Car, Electric Bicycle, etc.)
		T27	Electric Vehicle Charging Station Information
	16. Strengthening Resistance to Climate Change Risks	E12	Eco-friendly Food Waste Utilization
		E13	Smart Water Management
		E14	Indoor Air Quality Management for School and Kindergarten
		E15	Integrated Collection and Provision of Air Quality Information
		E16	Smart Street Lighting
		E17	Smart Trash Bin
		E18	Recycling and Sorting of Waste

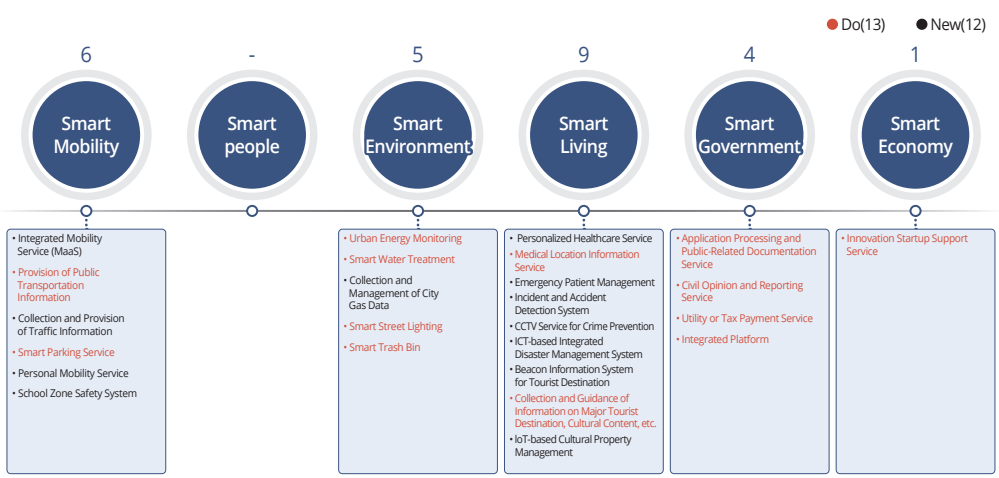
Table 4. (Continued)

Goal	Objective	Code	Smart City Service
	17. Development of Advanced Communication Infrastructure and Digital Transformation of the City	I1	Establishment of Digital Infrastructure
		P1	Urban Data Trading Platform
		P2	Integrated Platform

To realize the objectives outlined in the Development plan of the City of Zagreb, a comprehensive assessment revealed the necessity for 81 smart city services. When scrutinizing these services by sector, transportation emerges as the dominant category, encompassing 27 services. Energy and climate change response follows closely with 18 services, while urban safety accounts for 14 services.

To determine core smart city services for prioritized implementation, several factors were considered. First, the existing smart city status, including current initiatives and defined services, was assessed. Both candidate services and existing services were evaluated for their effectiveness post-implementation. While introducing new services is crucial, upgrading existing ones was also deemed important, as it often enhances service adoption feasibility. In summary, out of the 25 selected services, 13 require upgrades to existing services, while 12 are new services.

Figure 11.
Smart City Core Services



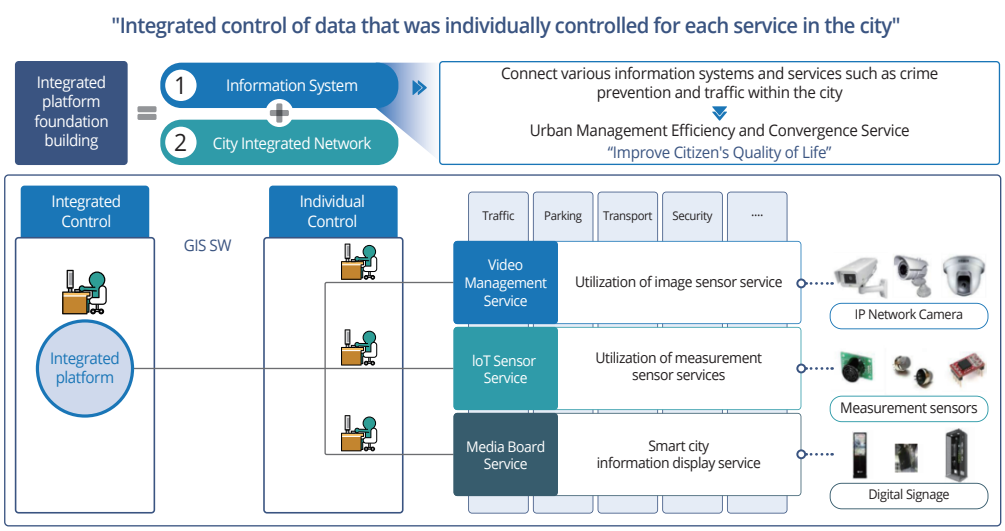
3.2. Establishing ICT Infrastructure

In Zagreb, each institution operates smart city services independently, lacking integration and data sharing among relevant agencies. The diagram below shows the current status of service operations, represented by the Integrated Platform. To enhance monitoring, it is crucial to integrate data from individually operated services by each institution.

For effective integrated operation monitoring, it is necessary to identify the agencies that require collaboration in responding to incidents and accidents. Additionally, it is essential to determine the entities that need to share data, CCTV footage, and situation dissemination (via SMS, VMS). By identifying and coordinating these entities, the effectiveness of smart city integrated operations can be maximized.

Introducing GIS integration enables comprehensive management of facility information for each service. Furthermore, during these operations, facility location information, CCTV camera locations, and footage can be managed together, facilitating an effective response to incidents, accidents, and routine operational situations.

Figure 12.
Integrated Operation Overview



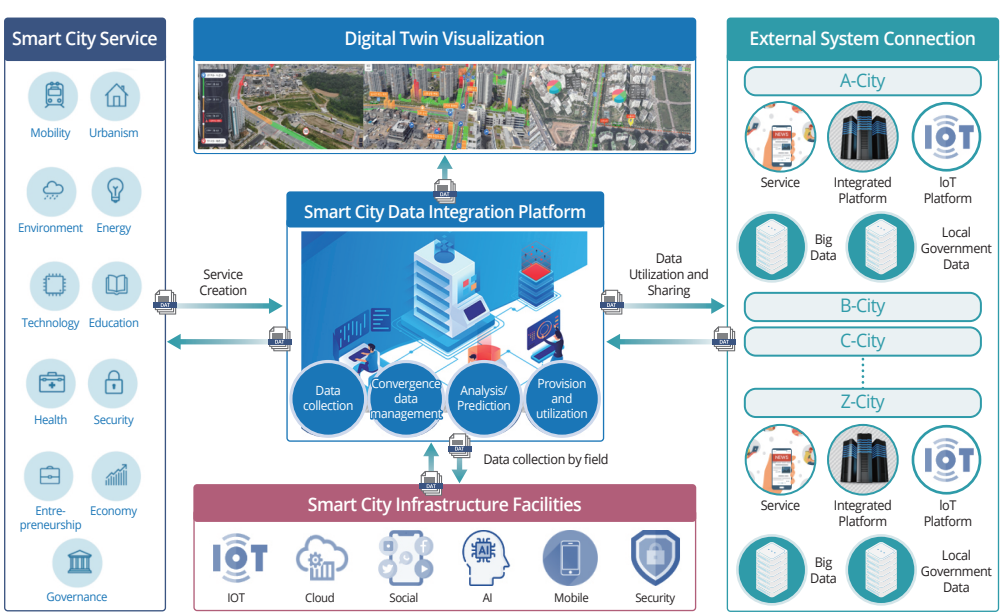
To facilitate the integrated operation of Zagreb's smart city initiatives, it is essential to introduce a Smart City Integrated Platform capable of integrating the services operated individually by each institution. Through the adoption of this platform, real-time data from various sources such as Traffic CCTV, Parking CCTV, Traffic Monitoring, Geo Hub Zagreb, ZET Center, Police, and ZagrebParking will be aggregated and stored. The types of data collected include CCTV Streaming, Traffic Information, Geo Data,

Public Transport Information, Wanted Vehicle Information, and Vehicle Number, thus allowing for integrated operation monitoring.

Utilizing the message routing feature of the Smart City Integrated Platform, the system identifies events (incidents, accidents) in real-time from the collected data. When an event occurs, the platform swiftly disseminates relevant information to the appropriate institutions based on the nature of the incident or accident. This facilitates prompt response, monitoring of progress, and efficient resolution of incidents and accidents.

By introducing a Smart City Integrated Platform, the city services in Zagreb requiring integration are selected and operated in a unified manner. The integration is implemented as depicted in the diagram "City Services Integration," and the integrated data is managed by establishing the Zagreb Integrated Control Center to aggregate and store the data. The collected data encompasses Traffic Data (such as traffic flow information, bus/tram GPS information, bus/tram line information, and traffic CCTV), Issue Data (involving car accidents, illegal trash disposal, noise complaints, violations, and civil complaints), Geo Hub Data (consisting of GIS map, public facilities data, cost progression, and project overview), and Parking Data (encompassing parking zone information, parking availability information, parking position information, license plate recognition, and parking CCTV).

Figure 13.
Integrated Platform Model



To expedite the implementation of Smart City initiatives and service integration in Zagreb, the establishment of a Smart City Integrated Platform and an Integrated Control Center is essential. The Integrated Control Center should be equipped with the necessary hardware, software, and infrastructure to support the operation of the Smart City Integrated Platform. Additionally, it should have a dedicated operational organization in place and establish operating procedures to ensure 24/7 monitoring of the city's status.

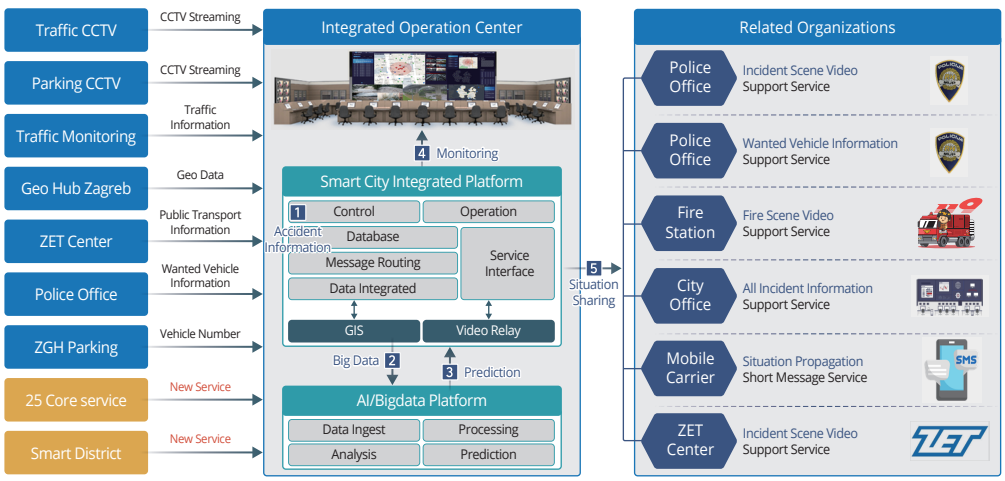
For the seamless monitoring of services at the Integrated Control Center, the development and implementation of a monitoring dashboard are crucial. The dashboard should include real-time data dashboards, GIS-based dashboards, data statistics management dashboards, event status dashboards, and other relevant components. The focus should be on real-time data monitoring, requiring enhancements to data collection methods in Zagreb.

The service data monitoring at the Integrated Control Center can be facilitated through video walls installed within the center. Additionally, individual desktops, smart pads, and mobile devices can be utilized by operators for monitoring purposes.

The integrated monitoring process involves the analysis and reporting of the following data:

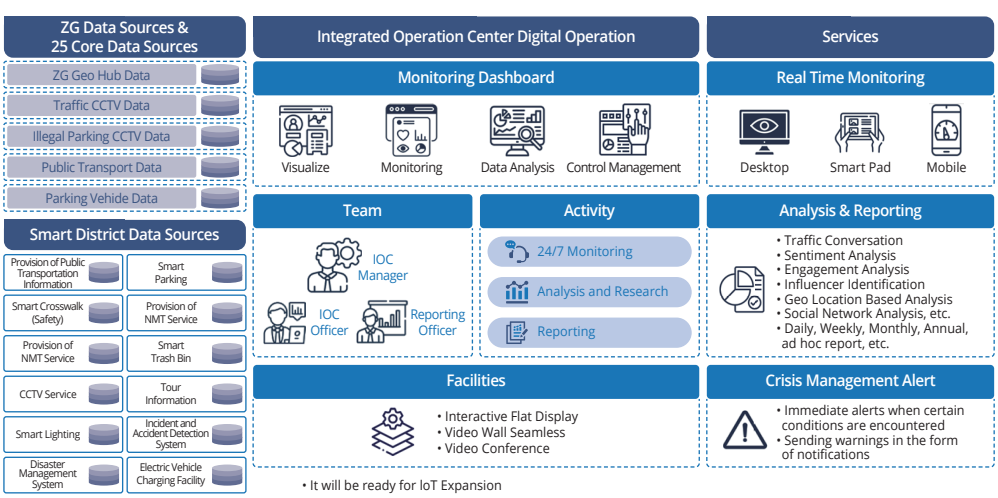
- Traffic Conversation
  - Collection and analysis of citizens' complaints regarding urban traffic
- Sentiment Analysis
  - Analysis of citizens' grievances (e.g., complaints and discomforts)
- Engagement Analysis
  - Analysis of citizen participation rates in city services (e.g., parking services, public transportation)
- Influencer Identification
  - Analysis of public opinion regarding key figures in events such as elections
- Geo Location Based Analysis
  - Analysis of city data using heat maps based on geographic locations (e.g., crime rates, population concentration areas)
- Social Network Analysis, etc.
- Daily, Weekly, Monthly, Annual, Ad hoc Reports, etc.
  - Reports on citizens' data as daily, weekly, monthly, annual, or ad hoc formats

Figure 14.
Integrated Control Center



Within the scope of this work, we introduce a diagram of the Integrated Operation Center. This is accomplished through the formation of an Integrated Operation Center and the implementation of a Smart City Integrated Platform.

Figure 15.
Grand Design Integrated Operation Center



The development of an integrated monitoring dashboard is essential for effective control center integration. This dashboard comprises various components, including a real-time data dashboard, a GIS-based dashboard, a data statistics management dashboard, and an event status dashboard.

Figure 16.
Integrated Monitoring Dashboard

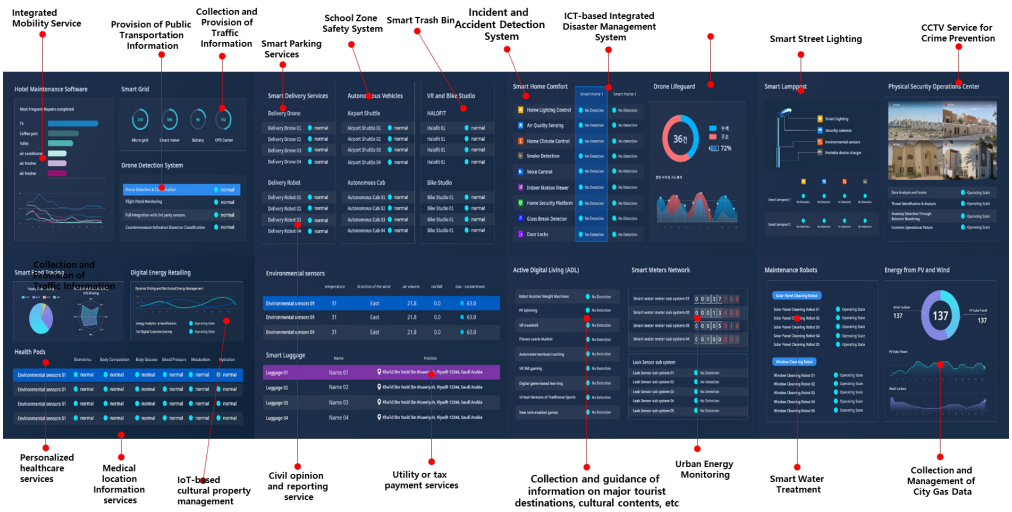


Table 5.
Integrated Control Center Budget Estimation (Hardware)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Smart city platform server configuration	Smart city platform server	20,000	6	120,000
	External data link server	20,000	6	120,000
	CCTV link server	20,000	6	120,000
	Various linked service management servers	20,000	6	120,000
	AI analysis server (graphics server)	70,000	2	140,000
	GIS server	20,000	6	120,000
	IoT platform server	20,000	3	60,000
Network equipment configuration	Backbone switch	70,000	1	70,000
	L3 switch	40,500	3	121,500
	L2 switch	30,000	6	180,000
	L4 switch	70,000	2	140,000
	Firewall	70,000	2	140,000
Video wall	Video wall monitor	6,000	18	108,000
	Video wall bracket	300	18	5,400
	Video wall frame	6,000	1	6,000
	IP wall controller	70,000	2	140,000
	Video cable	200	36	72,000

Table 5. (Continued)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Interior & infrastructure construction	Integrated operation center interior construction	27,000	1	27,000
	Electrical distribution boards, communication facilities, UPS, heating, and cooling construction, etc.			
Total Estimated Budget		EUR 1,809,900		

Table 6.
Integrated Control Center Budget Estimation (Software)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Platform license	Smart City Integrated Platform license	700,000	1	700,000
	IoT platform software license	150,000	1	150,000
	3D GIS simulation license	700,000	1	700,000
	VMS license	700,000	1	700,000
	CCTV video broadcasting video streaming license	70,000	1	70,000
	Service-linked module development cost	40,000	30	1,200,000
Commercial software	Cloud environment construction virtualization software	150,000	1	150,000
	Backup software	350,000	1	350,000
	WEB			
	WAS			
	DBMS			
	Redundant solution			
	Server OS			
	Others			
Total Estimated Budget		EUR 4,020,000		

3.3. Introduction of Smart District

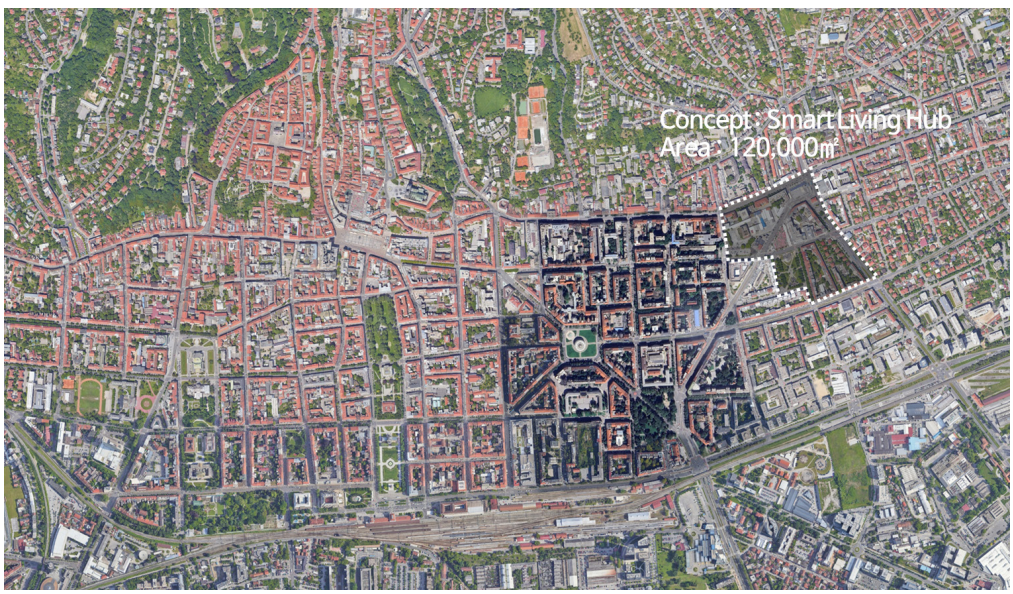
The Smart Districts initiative aims to achieve the following objectives:

- Technical validation of devices and services. To create an effective testbed for experimenting with the effects of smart cities by applying data collection and integrated operation through IoT devices.
- Efficient provision and integration of various services. To utilize smart city technology to enhance Zagreb's existing potential and improve convenience for citizens and tourists by creating new public spaces.
- Validation of the effectiveness of smart services. To improve the efficiency of existing urban infrastructure and facilities and foster the creation of new services through information integration.
- Enhancement of citizen and tourist acceptance of services. To provide services at opportune moments desired by citizens and tourists and ensure effective delivery and maintenance of urban lifestyle services.

Candidate areas for smart services were carefully selected based on specific objectives and characteristics. These areas would include public transportation hubs like tram, bus, train, and intercity bus stations, as well as areas adjacent to public garages. Highly frequented spots where both citizens and tourists pass by frequently were also considered. Proximity to landmarks, such as historical and administrative landmarks, was another important factor. Additionally, areas with minimal existing IoT infrastructure for service provision and minimal resistance to the installation of devices for smart services were prioritized. This selection process ensured that the candidate areas aligned with the above objectives and characteristics for smart services, making them suitable for the implementation of such services.

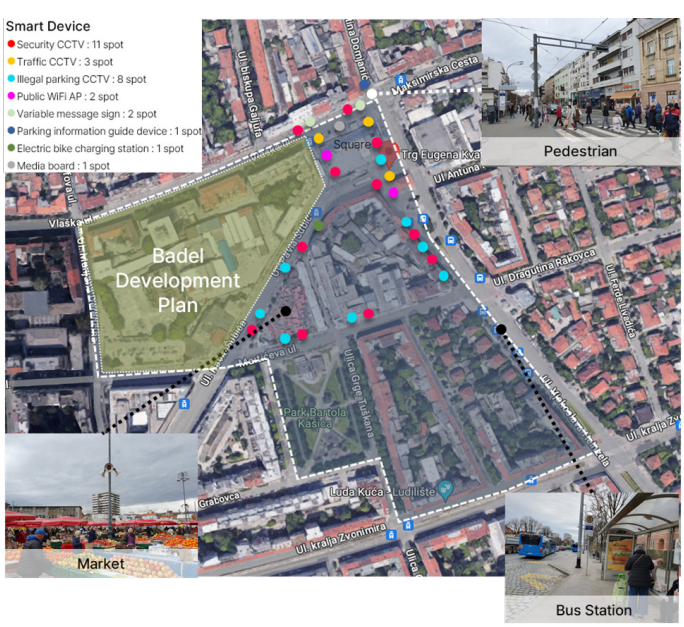
After reviewing the six candidate areas, Eugen Kvaternik Square was found to be a bustling area where citizens gather for daily activities, and with planned developments near the market, it is believed that synergies can be achieved. Therefore, Eugen Kvaternik Square has been chosen as the Smart District.

Figure 17.
Smart District Area (Eugen Kvaternik Square)



The Smart District, a popular destination, boasts markets, plazas, and a vibrant residential community, making it a densely populated region. Currently, the plaza is surrounded by ICT-related facilities, including safety CCTVs, traffic CCTVs, and illegal parking enforcement CCTVs, along with public Wi-Fi accessibility. In the tram section, VMS safeguards pedestrians, while the underground parking lot of the plaza provides real-time information on available parking spaces. Notably, the underground parking lot is equipped with electric vehicle charging stations.

Figure 18.
Status of Smart District



Within the designated area, distinct characteristics have been identified across different zones. However, the designated Smart District aims primarily to establish a transportation hub that prioritizes people's needs. Additionally, it seeks to create conditions for seamless information provision through public WiFi, offering services tailored to the characteristics of each zone.

First, the plaza is an area where many people gather and has the potential to become a public transportation hub, like a transit mall. The services in this area are designed with the goal of ensuring safe and convenient passage for people. The area near the market has commercial facilities but is characterized by older buildings. Therefore, the services in this area are designed with safety as the primary objective. The residential area situated at the lower part serves as a living space for its inhabitants. The services in this area aim to enhance the safety and convenience for the residents, catering to their specific needs. The park area is a space where citizens can relax. Accordingly, the services in this space are designed to ensure it is a convenient and safe place to rest.

The Smart District offers a range of services, including transportation-related services such as public transportation information, smart parking systems, smart crosswalks, and NMT (Non-Motorized Transport) services. In terms of safety, accident detection, evacuation services, and smart lighting are provided. Additionally, various other services such as cultural heritage protection and tour guides are offered. These various services enabled by ICT equipment allow the citizens a better quality of life.

Figure 19.
Smart District Service Location

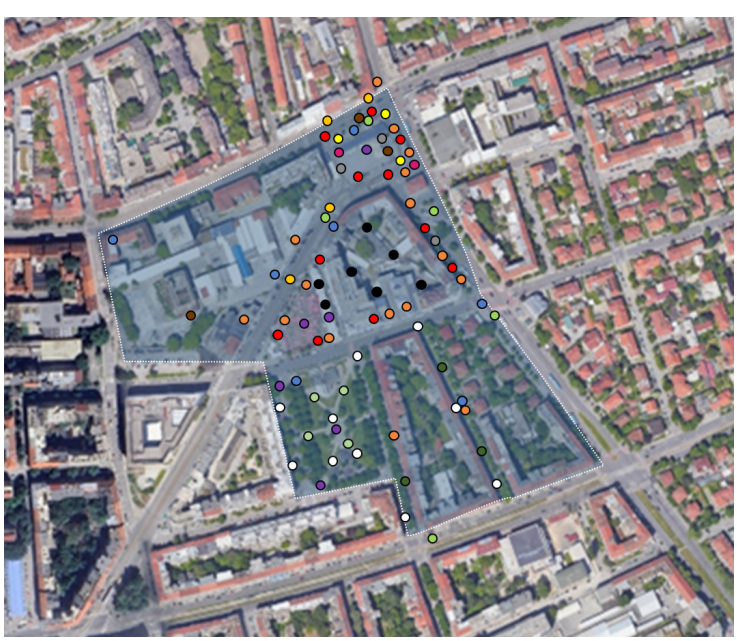


Figure 20.
Detailed Service of Smart District

Service	Detailed Service	Num. of Location
Provision of Public Transportation Information	Real-time Departure and Arrival Information (Tram, Bus) Real-time On-board Crowding Information (Tram, Bus) Real-time Information between Tram-Bus Stops (Departure, Arrival, Crowding)	5
Smart Parking	Parking Availability Information Provision Reservation and Payment System (Mobile or Kiosk) Illegal Parking Enforcement	16
Smart Crosswalk (Safety)	Speed Bump Guidance Pedestrian Alert System Pedestrian Signal Automatic Extension	4
Provision of NMT Service	Bicycle/PM Sharing Rack Locations and Availability Information Electric Bicycle Charging Station Locations and Availability Information Bicycle/PM Mobile Reservation and Payment Service	8
Smart Trash Bin	Automatic Trash Compaction Automatic Waste Quantity Notification System	5
CCTV Service	Detection and Alert of Hazardous Situations through Pedestrian Flow Monitoring Cultural Heritage Conservation	9
Tour Information	Guide to Nearby Tourist and Cultural Facilities	3
Smart Lighting	Automatic Light Adjustment Using IoT Sensors	10
Incident and Accident Detection System	Fire Monitoring System Electric Leakage Monitoring System Gas Leakage Detection System Odor Detection System	6
Disaster Management System	Emergency Evacuation Route Guidance System	1
Electric Vehicle Charging Facility	Expansion of Electric Vehicle/Bicycle Charging Facilities	4
Smart Bench	Integrated Lighting, Billboard or City Map, Wired/Wireless Charging, Free Wifi Service etc.	4

Table 7.
Component and Estimation Budget for ICT (Total)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Provision of Public Transportation Information/ Tour Information	Kiosk	95,000	4	380,000
	BIT			
	Tour Map			
	Smart Bench			
	Etc.			
Smart Parking	IoT parking lock	950	16	258,400
	Parking Space Construction	950		
	Operation Server	19,000	4	
	Parking App	47,500		

Table 7. (Continued)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Smart Crosswalk	Pedestrian detectors and voice guidance	66,500	4	684,000
	Floor-mounted pedestrian traffic lights	57,000	4	
	Integration of transportation operation center	95,000	2	
Provision of NMT Service	Electric bicycles	950	80	1,482,000
	Personal mobility	950	80	
	Stands (including charging capability)	95,000	8	
	App and operation server	47,500	4	
	Integration with the integrated platform	95,000	4	
Smart Trash Bin	Smart trash Bin	4,750	3	29,450
	Smart trash bin stands	1,900	3	
	App and operation server	9,500	1	
Security CCTV	Rotating CCTV	2,850	16	228,000
	Fixed 4 CCTV	3,800		
	Enclosure configuration (Electric/ Communication)	1,900		
	Emergency call button	950		
	CCTV Pole	4,750		
Traffic CCTV	Rotating CCTV	2,850	3	39,900
	Fixed 4 CCTV	3,800		
	Enclosure configuration (Electric/Communication)	1,900		
	CCTV Pole	4,750		
Smart LAMP	Smart pole LED lamps	28,500	10	285,000
Incident and Accident Detection System/ Disaster Management System	Rotating CCTV	2,850	1	27,550
	Fixed 4 CCTV	3,800		
	Enclosure configuration (Electric/Communication)	1,900		
	Emergency call button	4,750		
	CCTV Pole	9,500		
	Operation center disaster system (server, broadcasting equipment)	28,500	1	57,000
	Disaster detection solution	28,500	1	

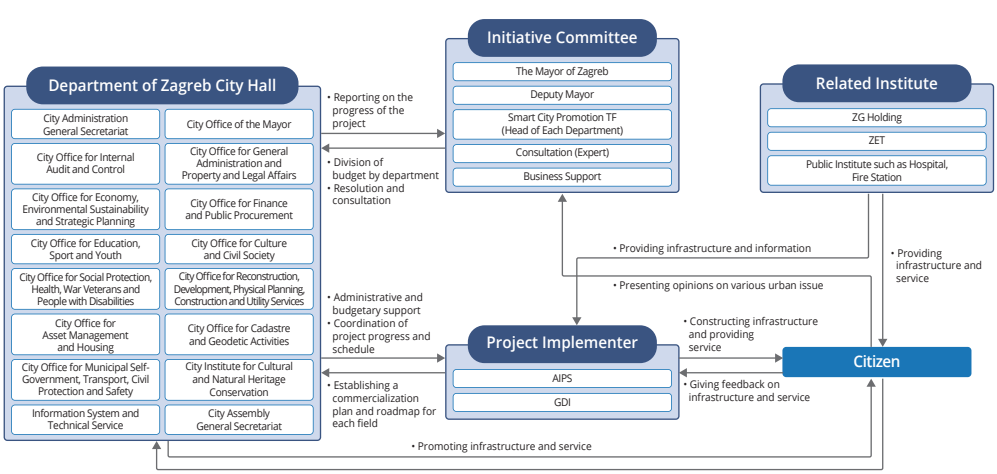
Table 7. (Continued)

Category	Unit	Unit Price (EUR)	No. of Unit	Cost (EUR)
Electric Vehicle Charging Facility	Electric Vehicle Charging Stand	95,000	4	380,000
Smart Bench	Smart bench	4,750	4	19,000
	Emergency call button, mobile phone charger Lighting, heating pads			
Public Wi-Fi	Wireless bridge	1,900	2	74,100
	Wireless Access Point (AP)	1,900	2	
	Wireless LAN Controller	9,500	1	
	Public Wi-Fi software	28,500	1	
	Public Wi-Fi Server	28,500	1	
Total Estimated Budget				EUR 3,944,400

3.4. Strategy for Improved Governance System

Drawing from previous case studies, I present a revised governance framework for Zagreb, guided by three key principles. Firstly, to mitigate the impact of the decentralized organizational structure, the establishment of a central steering committee is crucial. This committee will provide strategic guidance and ensure alignment across departments. Secondly, to foster inter-departmental collaboration, an enhanced communication and coordination system is necessary. Thirdly, to engage public and private enterprises actively, I propose assigning them the role of project implementers.

Figure 21.
Suggestions for Zagreb Smart City Governance



After studying the diagram, I've decided not to suggest a different relationship between the Initiative Committee and Project Implementers. Rather, I believe it would be more efficient for projects to go through the Zagreb City Administration. Presenting an alternative, however, might result in a more horizontal structure.

The Initiative Committee is the central decision-making body, responsible for overseeing strategic decisions and policy directions. Specific business support responsibilities are delegated to the City Office for Economy, Environmental Sustainability, and Strategic Planning. This delegation ensures focused attention on initiatives vital to economic development, environmental sustainability, and long-term strategic planning for the city.

Within the City of Zagreb, the City Office plays several vital roles. It serves as a bridge, offering administrative and budgetary assistance. The City Office takes charge of evaluating current infrastructure and services, pinpointing areas for enhancement or development. Additionally, it actively shapes regulations, laws, and policies, paving the way for smart city initiatives. To facilitate smooth operations and foster collaboration, the City Office sets up inter-departmental communication channels. Moreover, it ensures alignment and efficiency among all stakeholders by sharing project updates and synchronizing schedules.

The Project Implementer is tasked with establishing comprehensive business plans and roadmaps for two key areas: infrastructure development and service provision. These plans aim to strategically guide and oversee the implementation of projects crucial to enhancing infrastructure and delivering essential services effectively.

The Related Institute concentrates on crucial infrastructure, information, and service delivery within multiple sectors, such as public transportation, parking accessibility, gas distribution, waste management, water supply, healthcare provisions, and firefighting initiatives. Its primary purpose is to establish comprehensive planning and efficient management strategies to promote sustainable development and enhance operational effectiveness in these essential areas.

Citizens actively contribute to urban development by presenting diverse urban challenges that inspire innovative business solutions. Their valuable feedback on infrastructure and services is instrumental in identifying shortcomings and improving overall urban livability. Engaging with citizens and incorporating their input is paramount to fostering a responsive and sustainable urban environment that addresses their needs and aspirations.

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