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ORIGINAL

# IT Management Framework for Municipalities

## Modelo de gestión de las TIC en las municipalidades

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**ABSTRACT**

The integration of information technology (IT) into urban processes can significantly enhance public management by providing objective and timely information for decision-making at all levels of governance. It facilitates the administration and control of city resources, strengthens processes, and fosters greater citizen participation, efficiency, and transparency in their execution. This article proposes an IT management framework aligned with the smart city concept. The framework was organized into three levels of IT management: strategic, tactical, and operational, which corresponded to the city's maturity, intelligence, and technology, respectively. The model was based on best practices, international IT standards, and recognized theories. It was developed from the results of an instrument designed to quantify the indicators of two research variables: IT management and smart city, applied to the governing bodies of the city of Santa Marta, Colombia. The analysis of the responses allowed us to quantitatively and qualitatively describe the research variables and their interrelations. It also enabled us to identify strengths and weaknesses in order to make recommendations to improve the technological state and the development of services that increase the level of intelligence from the city of Santa Marta.

**Keywords:** Smart City; ITIL; COBIT; Urban Intelligence; Technology Maturity Level; Santa Marta.

**RESUMEN**

La integración de las tecnologías de la información y las comunicaciones (TIC), a los procesos de las ciudades puede contribuir al mejoramiento de la administración pública al proporcionar información precisa, confiable y oportuna para la toma de decisiones en todas las instancias gubernamentales; esto permite gestionar y supervisar los recursos de la ciudad, fortalece los procesos y fomenta la participación ciudadana, la eficiencia y la transparencia en su ejecución. El articulo propone un modelo de gestión de las TIC asociado al concepto de ciudad inteligente. El modelo se organiza en tres dimensiones: estrategia, táctica y operación, cada una asociada con la madurez, la inteligencia y la tecnología urbana, respectivamente. La iniciativa toma como referencia normas internacionales, buenas prácticas en TIC y reconocidas teorías, y fue elaborada a partir de los resultados de un instrumento diseñado para cuantificar los indicadores de las dimensiones de dos variables de investigación: gestión de las TIC y ciudad inteligente aplicado a los órganos de gobierno de la ciudad de Santa Marta. El análisis de las respuestas permitió describir cuantitativa y cualitativamente las variables de investigación y su interrelación, e identificar fortalezas y debilidades para hacer las recomendaciones para mejorar el estado tecnológico de la ciudad y el desarrollo de servicios que aumenten el grado de inteligencia de la ciudad de Santa Marta.

**Palabras clave:** Ciudad Inteligente; ITIL; COBIT; Inteligencia Urbana; Nivel de Madurez Tecnológica; Santa Marta.

## INTRODUCTION

A smart city is the modern concept of a city, where the economy, government, environment, inhabitants and environmental care work together in an intelligent symbiosis that improves the quality of life for its citizens. This process is based on an adequate integration and management of information and communication technologies.[1,2] Smart cities are characterized by leveraging hardware and software infrastructures to obtain, process and efficiently use information, in addition to integrating and automating their basic systems such as transportation, water, energy, among others. The purpose is to improve citizens' well-being and the city's infrastructure, with a focus on its sustainability and productive vocation.[3]

IT management in smart cities must adopt different approaches depending on the socioeconomic conditions of each city. IT management is understood as the process of adopting and implementing decisions regarding strategies, plans, and actions related to the creation, dissemination, and use of information and communication technologies. This management must be aligned with the general processes of innovation and development in these urban spaces.[4,5]

IT management in any organization or sector faces various challenges, such as the failure of IT projects due to factors like not generating the expected impact, the proposed solutions being specific rather than global, poor project monitoring, a lack of user engagement with the project, absence of regulations in certain cases, and sometimes, a lack of technical or business knowledge, among others. Additionally, it faces the high cost of IT projects, as most organizations fail to recognize the economic benefits derived from implementing IT in their processes, leading to the perception that IT projects are an expense rather than an investment. The lack of integration of technologies within the organization is another challenge: systems and information are not integrated or do not facilitate coordinated actions, as technological solutions are not always designed and implemented based on organizational needs and strategic objectives. There is also a gap between management and IT staff, as the differing perspectives of management and IT personnel hinder the synergy needed to achieve the organization's strategic goals. Finally, the lag of IT in relation to new trends is another obstacle: the services offered in organizations generally do not use cutting-edge technologies, which creates the perception that information systems and digital services are outdated.[6,7,8]

In addition, municipalities generate a vast amount of information, and managing it correctly, consistently, and efficiently presents a challenge. The lack of availability of information when it is absolutely necessary, or the presence of incorrect information even when available, creates frustration for citizens and leads to poor or irrelevant decisions by mayors. Providing municipal services relies heavily on precise information and the supporting IT infrastructure responsible for capturing, storing, and transmitting it. Ensuring that information-related IT is properly governed is of vital importance.[9,10]

**Table 1.** Operationalization of variables

| IT Management | | Smart City | |
|---|---|---|---|
| **Dimension** | **Indicator** | **Dimension** | **Indicator** |
| IT Governance | IT governance archetype<br>IT assessment<br>IT planning<br>IT monitoring | City maturity | Dispersed city<br>Integrated city<br>Connected city |
| IT Service | IT service strategy<br>IT service design<br>IT service transition<br>IT service operation<br>Continuous<br>IT improvement | City intelligence | Smart economy<br>Smart governance<br>Smart people<br>Smart living<br>Smart mobility<br>Smart environment |
| Information management | Ethical principles<br>Information systems<br>Information security | City Technology | Data collection<br>Data transmission<br>Data storage and analysis |
| Technology management | Identifying technology<br>Obtaining technology<br>Using technology | | Service and application platform |

The scientific literature presents various frameworks and models for IT management and governance in

different municipalities.[9,10,11,12,13] Most of these are based on ITIL and COBIT best practices. However, few of them align with smart city concepts, and even fewer are tailored to the needs of Latin American municipalities. Consequently, an IT Management Framework is proposed, offering specific recommendations to facilitate Santa Marta's transition into a smart city. The model presented in the article includes the system of variables described in table 1.

To formulate the model, research was carried out within the positivist paradigm. Initially, the context of IT in the city was analyzed using a conceptual framework, data collection and measurement techniques, as well as mathematical analysis and inference procedures. This approach allowed for the characterization of IT, its structure, and behavior within the city, and ultimately, the proposal of solutions to improve IT management.

An instrument was designed, validated, and applied to the city of Santa Marta to measure and describe the city's reality in terms of IT management and smart city development.

The instrument consists of three questions per indicator, totaling eighty-four closed-ended questions, each with five response alternatives on a Likert scale: always (5), almost always (4), sometimes (3), almost never (2), and never (1). To interpret the results, a scale was established with the following ranges and attributes: (i) ($1 \leq R < 1,8$): very poor; (ii) ($1,8 \leq R < 2,6$): poor; (iii) ($2,6 \leq R < 3,4$): average; (iv) ($3,4 \leq R < 4,2$): good; (v) ($4,2 \leq R \leq 5,0$): very good.

The framework aims to facilitate the development of IT management that generates strategic value for the city, enabling its rapid transformation into a smart city.

## METHOD

To validate the instrument, it was sent to academic peers for a psychometric evaluation of the developed items. Subsequently, a pilot test was conducted with six professionals who are experts in IT management, none of whom were part of the research population. The result was a Cronbach's alpha coefficient of 0,88.

The population for the instrument application consists of municipal secretariats, all offices affiliated with the mayor's office, and all decentralized public entities.

A diagnosis was made for each indicator, dimension, and variable proposed in the instrument, analyzing both the quantitative aspects and the qualitative elements derived from each response. A descriptive statistical analysis was performed for each of the items surveyed and, subsequently, for each dimension grouping certain indicators. The behavior of the variable was then observed globally using the mean of sample means.

Following this, the quantitative relationship between the IT Management and Smart City variables was analyzed. To achieve this, the data for the variables were organized, and the hypothesis that both are related was tested through the following analyses: covariance, which indicates that the two variables move in the same direction; the Pearson correlation coefficient, which evaluates the linear relationship between the two variables; and finally, the linear model of the variables and the coefficient of determination were expressed.

The conceptual structure of the IT Management Framework is defined based on theoretical concepts and the results obtained from the variance and covariance matrix of the dimensions of the variables. Additionally, the relationships between the elements are established, as well as the inputs and outputs associated with the management process. Guidelines were proposed to address the challenges identified and enhance the strengths found in the diagnosis. Furthermore, these guidelines were grouped and organized graphically.

## RESULTS AND DISCUSSION

### Analysis of the relationship between variables

By quantitatively analyzing the research variables, the alternative hypothesis that IT management and smart cities are related is tested. The points have a covariance of 0,456, indicating a direct relationship, where an increase in one variable leads to an increase in the other. The Pearson coefficient of 0,991 suggests a strong direct linear relationship between the variables.

The linear model between the variables, with IT Management as the independent variable and Smart City as the dependent variable, presents a positive slope of 0,85 and an intercept of 0,36. In addition, the model shows a coefficient of determination of 0,98, indicating that the data fit a linear regression model.

The covariance matrix of the dimensions of the two variables, which has positive values, supports the alignment and division of the proposed model explained below.

### IT management framework for smart cities

The proposal structures IT management into three levels: strategic, tactical, and operational, which are aligned with the dimensions of the smart city variable: city maturity, city intelligence, and city technology. Moreover, while the framework is based on the specific characteristics of the object of study, it has been designed in a generic manner to ensure its easy replication in any. See figure 1.

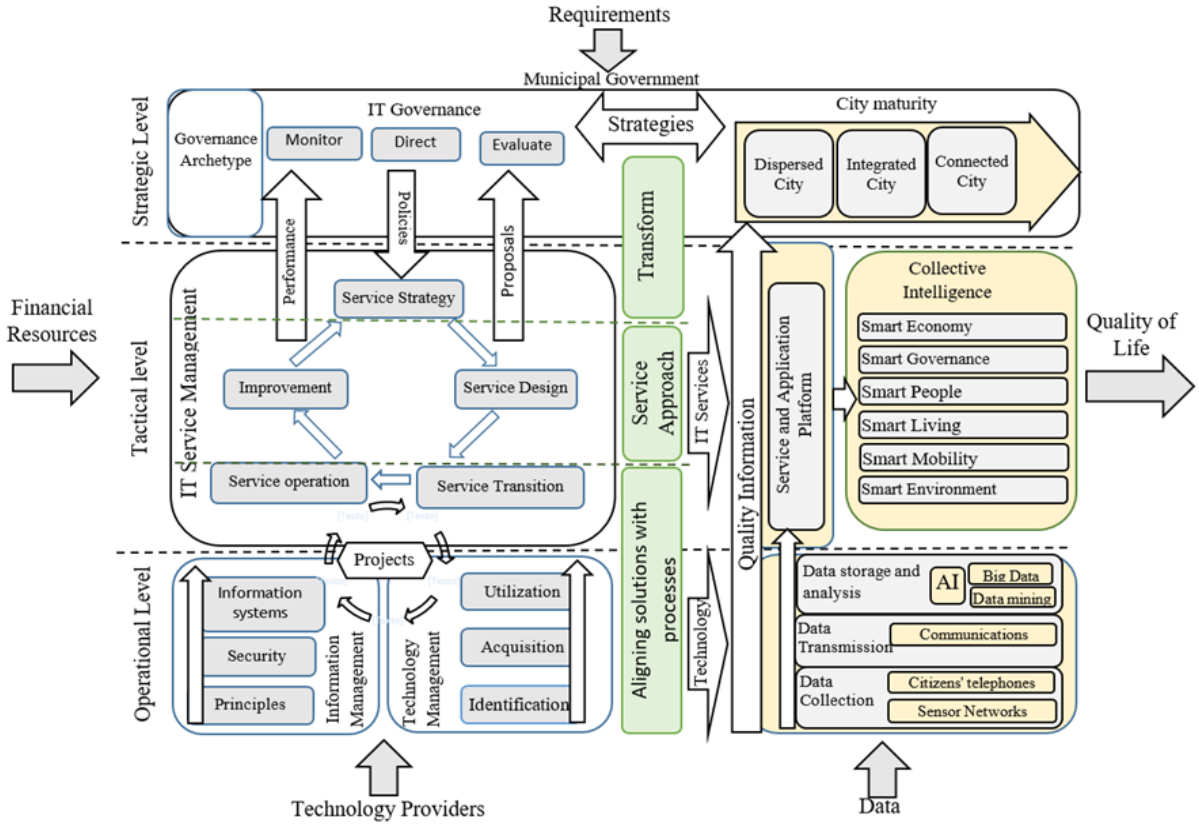


**Figure 1.** IT management framework for smart cities

### Diagnosis of the IT Management and Smart City variable

The general diagnosis of the variables in the city of Santa Marta can be seen in the following tables.

**Table 2.** Diagnosis of the IT Management

| Indicator | Mean | Dimension | Mean | $\sigma^2$ | Objective | Level | Attribute | Rating | $\sigma^2$ | Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| IT governance archetype | 2,41 | IT Governance | 2,49 | 0,19 | To describe the IT political strategies implemented in the city of Santa Marta | Strategic Level | Poor | 2,80 | 0,05 | Average |
| IT assessment | 2,05 | | | | | | | | | |
| IT planning | 2,29 | | | | | | | | | |
| IT monitoring | 3,21 | | | | | | | | | |
| IT service strategy | 2,85 | IT Service | 3,08 | 0,08 | To analyze the delivery of IT services within the public authorities of Santa Marta | Tactical Level | Average | | | |
| IT service design | 2,76 | | | | | | | | | |
| IT service transition | 2,96 | | | | | | | | | |
| IT service operation | 3,50 | | | | | | | | | |
| Continuous IT improvement | 3,33 | | | | | | | | | |
| Ethical principles | 2,86 | Information Management | 2,94 | 0,01 | To describe the operation of ICT within the public authorities of Santa Marta | Operational Level | Average | | | |
| Information systems | 2,85 | | | | | | | | | |
| Information security | 3,10 | | | | | | | | | |
| Identifying technology | 2,38 | Technology Management | 2,68 | 0,07 | | | | | | |
| Obtaining technology | 2,60 | | | | | | | | | |
| Using technology | 3,04 | | | | | | | | | |

**Table 3.** Diagnosis of the Smart City

| Indicator | Mean | Dimension | Mean | $\sigma^2$ | Objective | Level | Attribute | Rating | $\sigma^2$ | Assessment |
|---|---|---|---|---|---|---|---|---|---|---|
| Dispersed city | 2,77 | City Maturity | 1,94 | 0,38 | Evaluate the progress of Santa Marta's transformation into a smart city | Strategic Level | Poor | 2,01 | 0,21 | Poor |
| Integrated city | 1,78 | | | | | | | | | |
| Connected city | 1,28 | | | | | | | | | |
| Smart economy | 2,65 | City Intelligence | 2,29 | 0,13 | Determine the degree of collective intelligence in the city of Santa Marta | Tactical Level | Average | | | |
| Smart governance | 2,53 | | | | | | | | | |
| Smart people | 2,55 | | | | | | | | | |
| Smart living | 2,42 | | | | | | | | | |
| Smart mobility | 1,90 | | | | | | | | | |
| Smart environment | 1,69 | | | | | | | | | |
| Data collection | 1,21 | City Technology | 1,81 | 0,16 | Describe the technological status of the city of Santa Marta | Operational Level | Poor | | | |
| Data transmission | 2,26 | | | | | | | | | |
| Data storage and analysis | 2,09 | | | | | | | | | |
| Service and application platform | 1,68 | | | | | | | | | |

**Strategic Level**

This level encompasses IT governance, and it is here that IT technologies are strategically aligned with the city's objectives.

IT governance must ensure value delivery, resource optimization, risk minimization, and participation and transparency in decision-making.[14] To implement it, it is first necessary to establish the governance archetype, which will depend on the political characteristics of the city.[15] For example, a federal archetype is recommended, where decisions on investment and prioritization of IT infrastructure, IT architecture, current and future use of IT, and IT staff responsibilities are made by a committee with the participation of senior management, such as the mayor and secretaries, as well as the staff responsible for these technologies.

In addition, IT governance must answer the following questions: (i) What needs to be done in IT?; (ii) What are we going to do?; (iii) How are we going to do it?; (iv) How are we progressing?, and (v) Why is it being done?

To do this, three main processes need to be implemented: monitoring, directing and evaluating. (i) Monitoring: This process must measure the alignment of policies with current conditions, the performance of IT services and implementations, as well as staff compliance with their IT responsibilities. (ii) Directing: The management process must develop IT plans and policies that ensure the alignment of IT management with the city's political strategies. This requires considering the needs derived from the mayor's agenda and both the current and future IT capabilities of the city. (iii) Evaluate: This process involves recognizing and assessing IT management at all levels, the current state of IT systems, the integration of IT infrastructure with the city's broader infrastructure, and the decision-making processes related to IT.[16,17]

The main objective at this level is to achieve the evolution of a city into a smart city and reach the different levels of maturity until it becomes a connected city. A connected smart city has successfully developed intelligent initiatives that are part of an integrated plan and are managed according to the city model. This level is reached when information is proactively delivered to citizens at any time and place, without them having to search for it, combining global information with user profiles to generate timely and tailored data.[18]

**Tactical level**

This level represents the procedures used to obtain IT services that increase the degree of intelligence of the city. Its main focus is on quality services rather than IT infrastructure; in other words, it has a "service approach."

The degree of intelligence is related to the following areas:(i) smart economy, (ii) smart government, (iii) smart people, (iv) smart living, (v) smart mobility, and (vi) smart environment. Consequently, the IT services implemented must aim to address the weaknesses and needs in these areas by changing the conditions of the IT assets.[19,20,21]

The processes at this level are framed within the life cycle of an IT service and include: strategy, design, transition, operation, and improvement. (i) Service strategy: this process must generate a prioritized portfolio of IT services that aligns with the policies set by IT governance. (ii) Service design: this process involves performing detailed engineering of the services in the portfolio, including the design of new services and the modification and improvement of existing ones, as well as the development of the city's technological

plan. (iii) Service transition: this refers to the implementation of the IT services, it must be carried out in a planned manner, and it is recommended to evaluate user satisfaction when a new service is implemented. (iv) Service operation: this process ensures that IT services are provided efficiently and effectively on an ongoing basis. It involves enforcing the requirements associated with the service, satisfying user requests promptly, addressing service failures quickly, finding solutions to these errors, and eliminating potential service defects. (v) Continuous IT improvement: the objective of this phase is to continuously enhance the effectiveness and efficiency of IT processes and services.[22,23,24]

**Operational Level**

Information management and technology management form part of the operational level of IT management.

Information management should operate under clearly defined principles, ensuring adequate security levels and relying exclusively on integrated information systems. (i) Ethical principles associated with information management must be embedded throughout the information lifecycle from its creation or acquisition to its final disposal, such as elimination, archiving, or publication. This includes stages such as selection, combination, validation, debugging, and consolidation. The fundamental principles are as follows: all mayoral staff must identify, generate or acquire, refine, and share information and knowledge to effectively achieve the government's goals and objectives; information about the city must be accessible to citizens; and only high-quality information should support decision-making, provided by reliable information systems. To accomplish this, organizations must foster the dissemination and exchange of information, encouraging their members to recognize this process as a core value (ii) The information security process must protect information as a valuable asset. This involves implementing mechanisms and tools to safeguard against electronic attacks and promoting ethical behavior in managing this resource. (iii) Information systems should be integrated into both the mission processes and the support processes of the mayor's office, following a service-oriented architecture.[25,26]

Technology management encompasses three key processes: identifying, acquiring, and utilizing technology in the city. (i) The technology identification process focuses on discovering emerging and innovative technologies that address prioritized needs in the four technological domains of smart cities: data collection technologies, data transmission technologies, data storage and analysis technologies, and service and application platform technologies. Additionally, a technical and economic feasibility study of the alternatives to be acquired should be conducted. (ii) The technology acquisition process involves assessing the potential impact of integrating a technology, evaluating suppliers before procurement, and developing a technological acquisition plan. (iii) The technology utilization process ensures that the acquired IT is effectively used to enhance and innovate the city's processes and intelligence.[2,27]

## CONCLUSIONS

The variables IT Management and Smart City, along with their dimensions, exhibit a strong, direct, linear, and positive relationship. This finding supports the feasibility of developing and implementing a comprehensive IT management framework in cities, aligned with international standards and best management practices. Such a framework can be tailored to the specific needs of each city, providing a logical and flexible structure that integrates diverse practices and tools to optimize IT management. Consequently, it becomes possible to enhance the city's collective intelligence, technological maturity, and sustainability, with the goal of significantly improving the quality of life for its inhabitants.

Regarding the city of Santa Marta, the most relevant point is that while the city has smart city initiatives, it has not reached a mature level of a dispersed city nor achieved consistent implementation of smart city technologies. This is largely due to deficiencies in IT management at the strategic level, as well as the lack of a governance archetype that would enable the development of strategies and policies to transform IT services and infrastructure.

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