Journal on Interactive Systems, 2026, 17:1
ISSN: 2763-7719 • doi: 10.5753/jis.2026.7054

Research Paper

Design and Pilot Implementation of a Management Model for the Information and Communication Technology (ICT) Infrastructure and Platform Management (IPM) Practice in Municipal Public Administration

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Abstract. This paper proposes an Information and Communication Technology (ICT) infrastructure management model tailored to the operational reality of municipal public administration and grounded in the Information Technology Infrastructure Library version 4 (ITIL 4) Infrastructure and Platform Management (IPM) practice. A research gap was identified through a structured literature search that found no studies specifically addressing the application of the ITIL 4 IPM practice in municipal environments. Using the Design Science Research method, the model was developed and documented in Business Process Model and Notation (BPMN), integrating item classification, prioritisation routines and procedures adapted to resource-constrained public settings. A pilot execution in a municipal health unit demonstrated its applicability, revealing gaps in asset data, contributing to a more structured infrastructure assessment and supporting decision-making processes related to monitoring, risk mitigation and planned replacement of equipment. The results provide initial evidence that the model offers structural support and supports more consistent infrastructure analysis within the pilot context, indicating its potential to support maturity assessment across successive assessment cycles.

Keywords: ICT Infrastructure Management, ITIL 4, Public Value, Municipal Government

Edited by: Edna Dias Canedo | **Received:** 30 November 2025 • **Accepted:** 09 January 2026 • **Published:** 30 January 2026

1 Introduction

The presence of technology in public administration promotes transparency, accessibility, and reduced bureaucracy, allowing citizens to request and use services through electronic government platforms. The use of information technologies saves time and encourages active public participation in governmental processes. With the adoption of these technologies and the Internet, electronic government (e-government) has generated economic, social, and political impacts that strengthen citizens' connections with governmental institutions at all levels [Sampaio, 2017].

The expansion of digital public services was driven by the need to migrate many in-person services to remote formats, especially during the COVID-19 pandemic, which required rapid adaptations by governments to maintain essential service delivery [Branco Jr. and da Fonseca, 2023]. As a result, the acceleration of technological innovation has increased the demand for ICT infrastructure, including networks, servers, storage, and specialised software.

Ensuring efficient access to data and services remains a challenge in public administration: unstructured growth, slow procurement processes, and the absence of structured planning compromise performance and service reliability [Araújo, 2020].

In this context, the adoption of recognised frameworks seeks to support the efficient management of ICT infrastructure. ITIL 4, a consolidated framework for ICT service management, provides guidance that includes the technical practice of IPM, which supports the administration of these resources within organisational contexts [AXELOS, 2019].

The IPM practice, as defined by Pederson [2020], presents a structured approach for managing technological resources. However, as pointed out by Pereira and Silva [2010], *"the main problem in implementing ITIL lies in the fact that ITIL tells organisations 'what they must do' but does not make clear 'how they must do it'."* This gap between conceptual guidance and practical execution makes the structured adoption of these practices even more challenging in municipal public administration.

A relevant research gap was identified through a structured search conducted in Scopus, IEEE Xplore, and Google Scholar, which found no studies directly related to applying the ITIL 4 IPM practice in municipal public administrations. This preliminary gap analysis, complemented by the examination of existing systematic reviews and mappings such as those by Sengik and Lunardi [2023], Souza and Silva [2025], Santos and Moura [2024] and Karataş and Çakr [2023], confirms that most research on ICT governance in the public sector focuses on public universities and governmental agencies, with limited attention to municipal environments. Similarly, Sena [2018] had already pointed out this limitation before the release of ITIL 4, indicating that the gap persists.

This absence of publications indicates that, to date, the scientific literature has not sufficiently addressed the application of the ITIL 4 IPM practice in municipal public administration. Therefore, the present study seeks to fill this gap by investigating how this practice can be adapted and implemented in municipal contexts.

The research question guiding this work is: *"How can the development of an infrastructure management model based on ITIL 4 practices provide structural support aimed at improving efficiency, quality, and value delivery of ICT services in municipal public administration?"*

This article is an extended version of the Portuguese paper *"Um processo de Gerenciamento de Infraestrutura e Plataforma de TIC para Administração Pública Municipal: Avaliação de Maturidade Pré-Implantação"*, published in the LASDiGov proceedings at the XLV Brazilian Computer Society Congress [Galian *et al.*, 2025]. The original study presented a maturity diagnosis of ICT infrastructure management in a municipal government, based on the ITIL 4 IPM practice and a questionnaire applied to local specialists.

The results indicated dispersed routines, low formalisation, and the need for a structured management model to support service continuity and quality. In this extended version, the focus shifts to detailing the model's architecture, incorporating public-sector specificities, and illustrating how the model can guide municipalities in consolidating infrastructure management routines, with the aim of supporting the reliability of digital services.

This study aligns with II GranDSI-BR 2026–2036, particularly with the Eco(Systems²) of Information challenge, which highlights the need for structured models for integrated systems and infrastructure management [Araujo *et al.*, 2025]. The model presented responds to this agenda by detailing an ICT infrastructure management process based on the ITIL 4 IPM practice, documented in BPMN and applied in a pilot unit. The controlled execution enabled testing flows, validating artefacts, and demonstrating how the process can organise infrastructure routines in municipal environments.

This extended version goes beyond a new maturity diagnosis and shifts the focus to the operational detailing of the proposed model and its capacity to guide practical evolution in municipal ICT infrastructure management. The main contribution lies in the integration between a BPMN-based workflow, maturity evolution maps, and a continual improvement cycle, forming a structured mechanism that not only diagnoses the current state but also actively directs how municipalities can progress across maturity levels.

Unlike approaches centred on static assessments, this model was applied as a preliminary decision-support structure in a real municipal environment. This pilot application aimed to evaluate the integration of technical analysis, governance alignment, and procedural execution. The results suggest its potential to support structured progression and contribute to more consistent decision-making in future cycles.

2 Background

This section presents the main concepts that support this study and provides the foundation for the actions implemented in the proposed model, with emphasis on practices and concepts derived from ITIL 4.

2.1 ICT Infrastructure

ICT infrastructure encompasses the set of technological resources required to support an organisation's digital operations and services. This includes hardware, software, connectivity devices, networks, servers, storage, and cloud computing services, which are essential for information processing and storage [Cappellozza and Moraes, 2015]. In addition to physical and virtual equipment, infrastructure also includes operating systems, firmware, and management software that enable efficient operation and continuity of ICT services [Pederson, 2020].

Beyond its operational dimension, ICT infrastructure can also be understood from a strategic perspective, as the foundation upon which organisational technological capabilities are built. According to Weill and Ross [2004], the infrastructure consists of shared and centrally coordinated services that support an organisation's technological capacity and are often deployed before specific usage needs are fully identified. Given the complexity of ICT infrastructure, adopting established governance practices seeks to ensure more efficient management.

2.2 Governance Frameworks Applicable to ICT Infrastructure

Control Objectives for Information and Related Technologies (COBIT) 2019 is a framework focused on ICT governance and management, encompassing practices designed to ensure strategic alignment and organisational value creation [ISACA, 2018]. Although the framework establishes governance and management objectives and processes, it does not provide operational detail, remaining at a strategic and high-level perspective that indicates what must be done, but not how to do it. For this reason, COBIT is often combined with more operationally oriented frameworks such as ITIL and ISO/IEC 20000 (Information Technology Service Management Standard) [ISO/IEC, 2018].

ISO/IEC 20000, in turn, defines requirements for ICT service management, supporting the standardisation and quality of processes, but requires organisations to develop these processes without providing practical guidance [Silva Filho and Afonseca, 2025]. Although both address aspects of ICT infrastructure, ITIL 4 was selected because it offers detailed operational practices adaptable to the municipal context.

2.3 ITIL 4 and Management Practices

In this context, ITIL is a widely used framework for structuring and optimising service management practices. Created in the late 1980s by the Central Computer and Telecommunications Agency (CCTA), later renamed the Office of Government Commerce (OGC), the framework was originally designed to optimise the use of ICT resources in governmental environments [Ahriz *et al.*, 2021].

Over time, ITIL evolved significantly. ITIL v2, widely adopted in the 2000s, became known for standardising processes for service operation and support, mainly organised in the *Service Support* and *Service Delivery* books. Version 3, introduced in 2007 and revised in 2011, added a lifecycle approach to ICT service management. In 2019, the framework underwent a major revision, incorporating agile methodologies such as Lean, Agile, and DevOps, and emphasising customer experience and value creation [AXELOS, 2019].

Within ITIL 4's technical practices, IPM stands out as the practice responsible for the operational oversight of an organisation's technological resources [Pederson, 2020]. When properly applied, this practice enables continuous monitoring of technological resources, including those provided by external service providers, ensuring greater control over capacity, availability, and the operational status of adopted solutions.

Another relevant aspect of infrastructure management is the correct identification and control of assets. An ICT asset is any financially valuable component that contributes to service delivery, whereas a Configuration Item (CI) is an asset that becomes actively managed within the ICT infrastructure [AXELOS, 2019]. This distinction is particularly relevant in public administration, where procurement processes (Brazilian Law No. 14,133/2021)[1] require new resources to be inventoried before entering operation. Thus, assets are initially catalogued and later managed as CIs, ensuring more effective control of their use.

The proposed model also incorporates two additional ITIL 4 practices: Service Configuration Management (SCM) and Change Enablement (CE). In ITIL 4, SCM organises and maintains reliable information about services and configuration items (CIs), correlating components to show dependencies, impacts, and contributions of each element. In municipal environments, this supports a consistent inventory and provides the basis required for infrastructure management models in practice.

CE practice, formerly known as Change Control practice, defines how modifications to services and components are assessed, authorised, and executed, aiming to balance the need for change with the protection of services. Its objective is to increase the rate of successful changes through risk analysis, prioritisation, and stakeholder communication. When these practices are not yet implemented in the organisation, the proposed process provides alternative mechanisms that cover essential activities.

2.4 GUT Matrix

The Gravity, Urgency, and Tendency (GUT) prioritisation Matrix is a problem analysis tool that supports structured decision making through three criteria: severity, urgency, and trend. Each criterion receives a numerical score from 1 to 5, and the final prioritisation is obtained by multiplying these values. This approach helps classify actions according to the impact they generate when addressed or not, the immediacy with which they should be handled, and the likelihood that the situation will deteriorate if no intervention occurs. The structure used in this work is presented in Table 1.

As described by Paiva *et al*. [2021], the GUT Matrix has been adopted in public-sector ICT planning instruments, including the Information Technology Master Plan (acronym in Portuguese: Plano Diretor de Tecnologia da Informação - PDTI)[2], as a method for ranking needs and supporting resource allocation. Its structure assists managers in identifying which demands require faster intervention, which can be postponed without compromising service delivery, and which represent increasing risks if left unattended.

In the proposed model, the GUT Matrix provides an objective basis for analysing CIs by assigning comparable values to heterogeneous elements. This prevents decisions based solely on perception, distributes attention across all units under analysis, and ensures that prioritisation reflects both operational impact and the expected evolution of each identified issue.

2.5 BPMN

Business Process Model and Notation (BPMN) 2.0 is a consolidated standard for modelling organisational processes using a visual notation capable of representing activities, events, decisions, and interactions in a structured and comprehensible manner. Its graphical elements support a shared understanding among analysts, managers, and technical teams, which is particularly relevant in public administration scenarios that require transparency, standardisation, and reproducible documentation. According to Garcia [2022], the evolution of BPMN has expanded its expressiveness through constructs such as parallel gateways, conditional events, and iterative structures, enabling the modelling of increasingly complex processes without compromising readability.

In the context of the proposed ICT IPM model, BPMN provides a coherent mechanism to represent the workflow executed across the four stages of the model. Start and end events delimit process boundaries, gateways depict decision points such as the need to trigger CE practice, and lanes indicate the distribution of responsibilities among infrastructure teams, support personnel, and governance actors. This structure clarifies how information flows between activities and how each role contributes to the execution of the management routine.

An additional advantage of modelling the workflow in BPMN is the ability to visualise how emergency conditions and unexpected situations are handled during execution. In traditional checklists or static TO-DO lists used for infrastructure management, the discovery of an urgent incident may interrupt the assessment or shift the focus exclusively to the immediate problem, compromising the completeness of the overall process.

In the BPMN model, these situations are incorporated into the flow through decision points and structured interactions with existing organisational practices. When a critical issue is identified during data collection or analysis, the model allows the corresponding process, such as CE practice or incident handling, to be triggered without interrupting the overall workflow. This ensures continuity of the assessment while still addressing urgent demands, preserving both procedural completeness and operational responsiveness.

To ensure proper readability within the two-column layout of this article, the BPMN diagram is presented on a single page in portrait orientation while maintaining all subprocesses and decision structures of the workflow without simplification. A high-resolution landscape version of the complete diagram will also be made available in the *"Availability of data and materials"* section, allowing full visualisation of the model and supporting its reuse and verification in future studies.

[1] Brazilian Public Procurement and Administrative Contracts Law (Lei n.º 14.133, de 1º de abril de 2021). Available at: https://www.planalto.gov.br/l14133. Accessed on 22 January 2026.

[2] PDTI: a planning and management instrument that defines diagnosis, priorities, governance structures, and ICT-related actions within a public organisation, aligning ICT strategy with institutional objectives [Brasil, 2022].

2.6 Adapting the Practice to Different Contexts

The adoption of service or project management frameworks and methodologies, such as ITIL 4, may require practices to be adjusted to the specific characteristics of the organisation and the environment in which they will be implemented. This adaptation process is known as *tailoring* and is present in several internationally recognised methodologies.

In the context of Projects in Controlled Environments version 2 (PRINCE2), maintained by AXELOS, tailoring appears among the seven fundamental principles, described as *"Tailor to suit the project"*, which guides the adjustment of the methodology according to the environment, size, complexity, relevance, and risk level of the project [AXELOS, 2017]. This flexibility seeks to balance governance and control with the need to avoid excessive bureaucracy or superficial approaches.

The concept of tailoring is also addressed by the Project Management Institute (PMI) in the PMBOK® Guide – Seventh Edition [PMI, 2021], where it is defined as the deliberate selection and modification of methods, processes, and elements of the value delivery system to meet the specific needs of a project or organisation. The guide states that tailoring should consider factors such as organisational culture, size, maturity, complexity, available resources, risks, and external constraints in real implementation scenarios.

In the proposed management model, tailoring plays a central role by allowing model steps such as data collection, item classification, or change recording to be adjusted to the existing operational capacity, maintaining ITIL 4 logic without imposing requirements that are incompatible with the municipal reality. This approach ensures that the model remains applicable even in environments with low initial maturity.

2.7 Public Value

Moore [1995] proposed that the role of public managers is to create public value, understood as the generation of social benefits aligned with the expectations and needs of society rather than simply pursuing administrative efficiency. This perspective provides a conceptual foundation for evaluating public policies, services, and assets, guiding decisions that incorporate collective interests into governmental action.

Meynhardt [2015] emphasises that public value cannot be understood solely in objective or financial terms, as it is intrinsically connected to citizens' social, ethical, and emotional perceptions. The author proposes assessing public value through five dimensions: utilitarian-instrumental, moral-ethical, political-social, hedonistic-aesthetic, and financial-economic, broadening the understanding of how citizens perceive the impact of public sector actions.

In the context of ICT infrastructure, this approach helps to distinguish between investments that genuinely enhance service delivery and those that generate limited or indirect benefits. Public value analysis allows managers to interpret technical components not only as operational assets but also as enablers of service continuity, accessibility, and user experience. This broader perspective becomes essential in resource-constrained environments, where decisions must balance technical feasibility with the concrete effects perceived by citizens.

A practical example illustrates this point. In the absence of a public value perspective, decisions may prioritise upgrades that appear urgent from a technical standpoint but do not meaningfully improve service delivery. This may lead to replacing cabling with a higher-grade technology even when the existing infrastructure still meets bandwidth requirements, while the real limitation experienced by users is the absence of wireless access in the unit. Similarly, an organisation may invest in a higher-capacity server while long queues in the taxation department are actually caused by slow Internet connectivity rather than processing capacity constraints.

By analysing CIs according to their contribution to public value delivery, the proposed model helps redirect attention to the elements that genuinely affect the quality of public services. This preventing misaligned or low-impact interventions and ensuring resources are allocated where they generate the greatest service impact. According to Santana *et al.* [2024], this integration must acknowledge the complexity of factors shaping public perceptions, including technical efficiency, social justice, civic participation, and collective well-being.

Consequently, this work adopts public value as a guiding criterion for classifying infrastructure CIs. It proposes that these components be assessed not only by their technical relevance but also by their direct and indirect contribution to public value creation within municipal administration. This approach ensures that the management of technical assets remains inherently connected to the social objectives of the municipal public sector.

2.8 Related Work

Research on ICT infrastructure management in public administration is dispersed across studies on governance, strategic planning, ITSM adoption, and maturity assessment. In Brazilian venues and in international public-sector settings, the literature typically addresses these dimensions in isolation, without consolidating an end-to-end Infrastructure and Platform Management (IPM) process aligned with ITIL 4 and tailored to municipal constraints. These governance and operational perspectives connect directly to broader digital transformation initiatives, often discussed under smart city and digital government agendas.

In Brazil, smart city and digital government discussions frequently emphasise governance structures and planning arrangements. A governance structure for ICT in smart cities was proposed with an enterprise architecture perspective [Tanaka *et al.*, 2018]. Empirical investigations in municipalities also indicate that, even in cities associated with smart initiatives, governance instruments and routines are often incomplete or inconsistently adopted [Reis *et al.*, 2020, 2021a,b]. These findings reinforce that digital services and smart city labels do not necessarily translate into stable operational routines for infrastructure management.

Brazilian SBC venues have also reported initiatives closer to ITSM and process organisation in public organisations. A federal agency case (ANCINE) reported actions related to ITIL-based service catalogue management in the context of internal transformation efforts [Oliveira and Schneider, 2024]. In public educational institutions, a Service Desk quality framework discusses operational controls and the use of configuration information, including CMDB-related elements [da Silva and Vasconcelos, 2017]. From a broader process capability perspective, a study assessed critical ICT

Table 1. GUT Prioritisation Matrix

Weight	Severity (G)	Urgency (U)	Trend (T)
5	Failure point; security risks; strategic solution.	Immediate action required; legal deadline under 3 months.	Interrupts service delivery.
4	Very severe; impacts processes and routines.	Some urgency; legal requirement between 3 and 6 months.	Prevents service delivery.
3	Severe; impacts systems and hardware architecture.	As soon as possible; implementation time between 6 and 12 months.	Prevents meeting service delivery deadlines.
2	Low severity; impacts management and full performance.	Can wait; implementation time between 12 and 24 months.	Makes service delivery more difficult.
1	No severity; minor improvements; contributes to nonconformities.	No rush; implementation time above 24 months.	Does not interfere with service delivery.

processes in a public-sector IT directorate using COBIT 5, reinforcing the need for formal process definition and measurement [Silva *et al.*, 2017]. Governance-oriented approaches have also been applied in Brazilian public settings, such as the adoption of an agile governance framework (ManGve) in a public organisation [Arcanjo *et al.*, 2019]. Recent LASDiGov contributions further illustrate the use of process mapping and BPM-oriented approaches in government contexts, although not focused on IPM [Nascimento *et al.*, 2025; Vasconcelos *et al.*, 2025; Vasconcelos and Marques, 2025].

At the federal level, a maturity model was developed for agencies within SISP [Santos *et al.*, 2020], structured around organisational culture, internal controls, and performance. Although focused on federal organisations, it supports the view that maturity assessment requires combining technical and organisational dimensions, which also applies to municipalities. In addition, critical success factors for ITIL adoption in the public sector highlight senior management support, training, and tool usage, reinforcing that technical practices depend on institutional readiness [Oliveira *et al.*, 2020].

International public environments report ITIL-aligned efforts focused on indicators, incidents, configuration-related controls, and governance integration [Prabowo and Rosalinda, 2022; Dzemydienė *et al.*, 2023; Machaladze, 2025; Sarwar *et al.*, 2023]. Complementarily, technical literature has discussed the evolution of configuration management and related trends, such as DevOps, Infrastructure as Code, and CMDB developments [Farayola *et al.*, 2023]. Smart city and digital transformation research also stresses that value creation depends on governance arrangements capable of coordinating actors, defining responsibilities, and sustaining continual improvement [Cosgrave *et al.*, 2014; Das, 2024; Xie *et al.*, 2024; Zyzak *et al.*, 2024].

To make the distinction explicit, related work predominantly provides governance and planning perspectives for smart cities and digital government, maturity models and adoption factors at broader organisational levels, or isolated process proposals and assessments (for example, service catalogue initiatives, Service Desk quality frameworks, risk management, and investment decision processes). In contrast, this article delivers an integrated municipal IPM workflow aligned with the ITIL 4 IPM practice, modelled in BPMN with defined roles, inputs, outputs, and supporting artefacts, and anchored in a baseline maturity diagnosis that guides prioritisation and subsequent continual improvement cycles.

3 Methodology

This section first reports the procedures used to identify and justify the research gap that motivates the study, including a structured ad hoc search strategy. It then presents the research design, which adopts the Design Science Research (DSR) approach as proposed by Peffers *et al.* [2007], and describes each DSR stage and the associated outputs.

3.1 Research gap identification strategy

Identifying the research gap followed a two-step strategy. First, we performed a structured ad hoc search in September 2024 in Scopus, IEEE Xplore, and Google Scholar, aiming to locate publications addressing the application of the ITIL 4 IPM practice in municipal public administration. The searches were limited to publications after 2019, the year ITIL 4 was released, in order to maximise the retrieval of recent studies grounded in this framework. In Scopus, the search in *Article Title, Abstract, Keywords* combined the terms `"ITIL"` AND (`"infrastructure management"` OR `"infrastructure and platform management"`), and additional public-sector terms were tested (for example, `"public sector"` and `"government institutions"`). Equivalent queries were executed in IEEE Xplore and Google Scholar.

In addition, we searched the SBC OpenLib (SOL) to identify Brazilian studies in SBC venues; while the search returned works related to digital government, none directly addressed ITIL 4 IPM as an operational process for municipal public administration. To align the search with the submission venue, we also consulted the Journal on Interactive Systems (JIS) archive using the same keyword set. This journal-level search returned studies related to government-facing digital services and e-government interaction (e.g., [Monteiro *et al.*, 2023; Vieira and Andrade, 2024]); however, the search did not return studies that directly address ITIL/ITSM or Infrastructure and Platform Management as an operational process for municipal public administration.

Second, we examined published systematic literature reviews and systematic mapping studies on ICT governance in the public sector to verify whether they reported studies focused on IPM aligned with ITIL, particularly in municipal contexts. This combined strategy was used to support gap identification and positioning and does not constitute a standalone systematic literature review. No additional records were identified that matched the intended scope of ITIL 4 IPM applied to municipal public administration beyond the authors' own prior publications on the topic. The results of this preliminary gap analysis were not published as a standalone article; instead, they are integrated into this study to provide the empirical and theoretical foundation for the 'Problem Identification and Motivation' stage of the DSR process described below.

3.2 Design Science Research

This study adopts the Design Science Research (DSR) approach, as proposed by Peffers et al. [Peffers *et al.*, 2007], due to its suitability for developing artefacts applicable to ICT infrastructure management. The process is structured into six stages: Problem Identification and Motivation, Objectives of a Solution, Design and Development, Demonstration, Evaluation, and Communication. Figure 1, adapted from [Peffers *et al.*, 2007], provides a graphical overview of the stages discussed below.

3.3 Problem Identification and Motivation

The municipality under study celebrated its 78th anniversary in 2025. It is classified as a large municipality in the GP1A category[3]. It has an estimated population of 124,838 inhabitants for 2025 and an HDI of 0.748, based on the 2022 Census data [IBGE, 2023].

The city offers various online services and promotes digital inclusion in public spaces. In 2023, the local administration implemented the PDTI, following national guidelines for establishing ICT governance [Brasil, 2022]. Nevertheless, the translation of strategic planning into consistent operational practices for ICT infrastructure management remains limited, particularly regarding asset classification, prioritisation of interventions, and decision support for maintenance and replacement actions.

In the problem identification and motivation stage, a bibliographic and documentary review was conducted, examining publications on infrastructure management and official government documents. The objective of this stage was to identify existing practices and understand the administrative characteristics that influence infrastructure management in municipal ICT environments, in order to characterise the problem context. This gap motivates the development of a structured and context-aware approach to ICT infrastructure management tailored to municipal public administration.

3.4 Objectives of a Solution

Based on the identified problem, the main objective of this study was defined as the development of an ICT infrastructure management model, grounded in the ITIL 4 IPM practice and adapted to the needs of municipal public administration, providing structural support for improvements in efficiency, quality, and value delivery of ICT services.

In addition to this general objective, the proposed solution aims to provide a structured and operational model capable of supporting the systematic analysis of infrastructure assets, the prioritisation of interventions, and informed decision-making regarding maintenance and replacement actions. The model is intended to be applicable within resource-constrained public environments and to support iterative use across successive implementation cycles, without presupposing immediate performance gains.

3.5 Design and Development

In the design and development stage, a management model grounded in the ITIL 4 IPM practice and tailored to the needs of municipal public administration was elaborated. This stage focused on translating the conceptual guidance of the IPM practice into an operational model compatible with the constraints and characteristics of the municipal context.

Initially, the core activities and decision points of the ITIL 4 IPM practice were analysed and mapped to the operational reality of municipal public administration. This analysis also considered dependencies and interfaces with related practices responsible for asset control, configuration items, inventory data management, and change enablement, ensuring coherence with existing governance and operational structures. These activities were then organised into a coherent process flow, defining inputs, outputs, roles, and responsibilities, with attention to existing organisational structures and resource limitations.

Subsequently, the structured process flow was modelled using the BPMN standard, enabling the explicit representation of execution logic, information flows, and role interactions. In parallel, supporting artefacts, such as templates and classification criteria, were defined to ensure the operational applicability and practical use of the proposed model.

3.6 Demonstration

In the Demonstration stage, the proposed model was executed in a pilot implementation within a municipal health complex. The objective of this stage was to verify the operational feasibility of the proposed model, observe the execution of its activities, and assess whether the proposed model could be applied within real municipal constraints.

The pilot execution enabled the observation of process flows, the use of templates, and the interaction between roles defined in the BPMN model. Full implementation across the entire municipal infrastructure was not intended at this stage and remains planned for future cycles. In accordance with the DSR approach, this execution represents an initial demonstration of applicability rather than a complete evaluation of outcomes.

It is important to highlight that the execution of the model occurred after the application of the Diagnostic Assessment Questionnaire (QAD), which was conducted prior to any intervention to establish a baseline of ICT infrastructure management maturity. The QAD does not constitute part of the Demonstration stage, nor does it correspond to the Evaluation stage defined in DSR; instead, it functions exclusively as a baseline reference to support the interpretation of future changes within the proposed research context.

The results obtained during this stage should therefore be interpreted strictly as evidence of feasibility and coherence of the proposed workflow in a real municipal environment. They do not represent measured improvements in efficiency,

[3] GP1A is a technical classification for municipalities used by the Unified Social Assistance System in Brazil (acronym in Portuguese: SUAS). The label GP1A corresponds to the Portuguese category *Grande Porte 1A*. It applies to municipalities with populations between 100,001 and 900,000 inhabitants and is used to define the expected complexity of social assistance services and the scale of federal funding [Brasil, 2015].

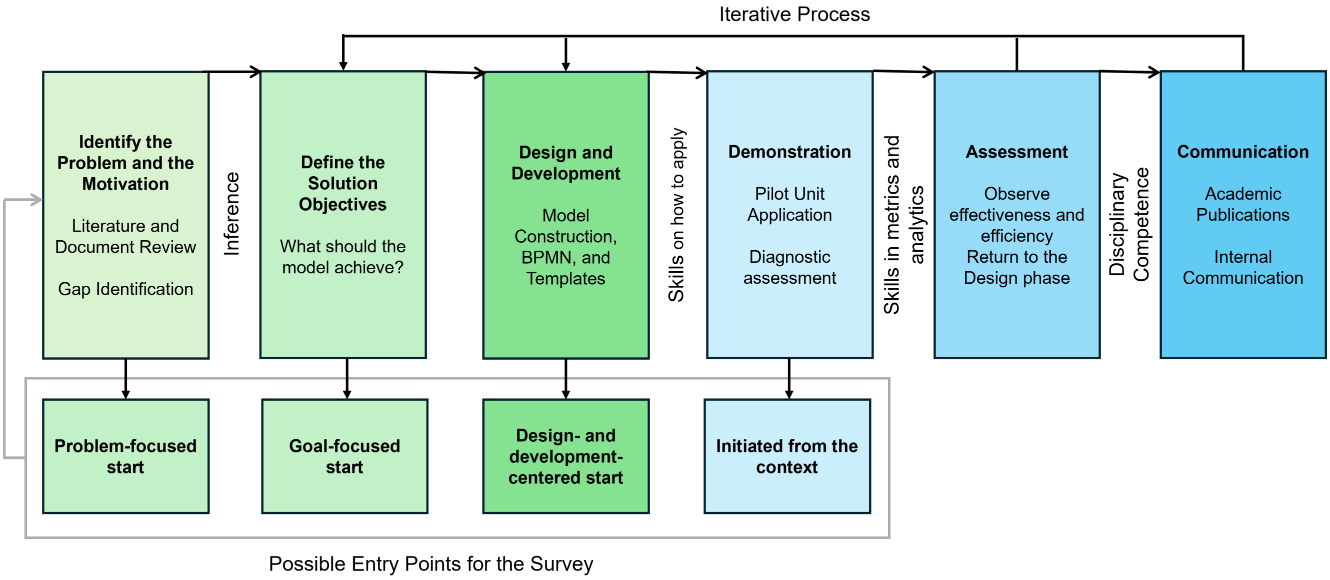

Figure 1. Adapted Design Science Research cycle used in this study, based on Peffers *et al.* [2007]

quality, or value delivery, which will only be assessed after full implementation and subsequent evaluation cycles.

3.7 Evaluation

The formal evaluation of the proposed model, as defined in the DSR methodology, will only be conducted after full implementation of the model across a broader set of municipal units. At the current stage, no quantitative or outcome-based evaluation was performed.

Although a full evaluation was not conducted at this stage, preliminary evaluation activities were performed during the pilot execution. These activities consisted of structured observations of the model execution in a municipal health unit, focusing on the clarity of process steps, the logical consistency between activities, the adequacy of defined roles, and the feasibility of execution within existing organisational and resource constraints.

These observations do not constitute an assessment of performance improvements, service quality, efficiency gains, or value delivery outcomes. Instead, they provide preliminary evidence that the proposed model can be executed as designed in a real municipal environment, serving as an initial validation of feasibility rather than effectiveness.

The complete evaluation stage, including the use of quantitative indicators and comparative analysis across successive cycles, is planned as future work and will be supported by the reapplication of the maturity assessment and the systematic analysis of operational data generated after full implementation across subsequent evaluation cycles.

3.8 Communication

The Communication stage is addressed through the documentation and dissemination of the proposed model, including the BPMN representation of the process and the reporting of the pilot execution and its associated reflections. This publication fulfils this stage by communicating the design rationale, implementation context, and initial demonstration results. In addition to supporting internal communication within the municipal context, this and prior related publications also contribute to external dissemination by sharing the proposed approach and its empirical insights with the broader academic and practitioner communities. The Communication stage will be revisited in future work to report the outcomes of full implementation and subsequent maturity reassessment.

4 ICT Infrastructure Management Model

The ICT infrastructure management model was documented using BPMN notation, providing a structured visualisation of the activities, responsibilities, and interactions involved. The choice of BPMN supports clarity for technical teams and ensures a unified representation of the process flow across execution cycles.

The BPMN flow presented in Figure 2 remains structurally unchanged from the originally proposed version. In this extended study, the contribution lies in the operational detailing of the workflow, its contextualization within the municipal public administration environment, and its execution in a pilot unit. This comprehensive visualization is displayed in landscape orientation to accommodate its horizontal extension and ensure the clarity of all technical elements, particularly the four color-coded stages. For a more granular inspection, the original high-resolution model and the corresponding .bpmn source file are available as supplementary material, allowing for visualization in its native landscape format.

The model is organised into four stages: Data Collection and Classification, Detailed Analysis and prioritisation, Partial Report Development, and Infrastructure Improvement Plan Development. The subsections below describe each stage and present the corresponding tables with inputs, activities, executors, outputs, and required resources.

4.1 Stages of the Proposed Model

4.1.1 *Data Collection and Classification*

This initial stage involves gathering detailed information about the ICT infrastructure present in each government unit. The

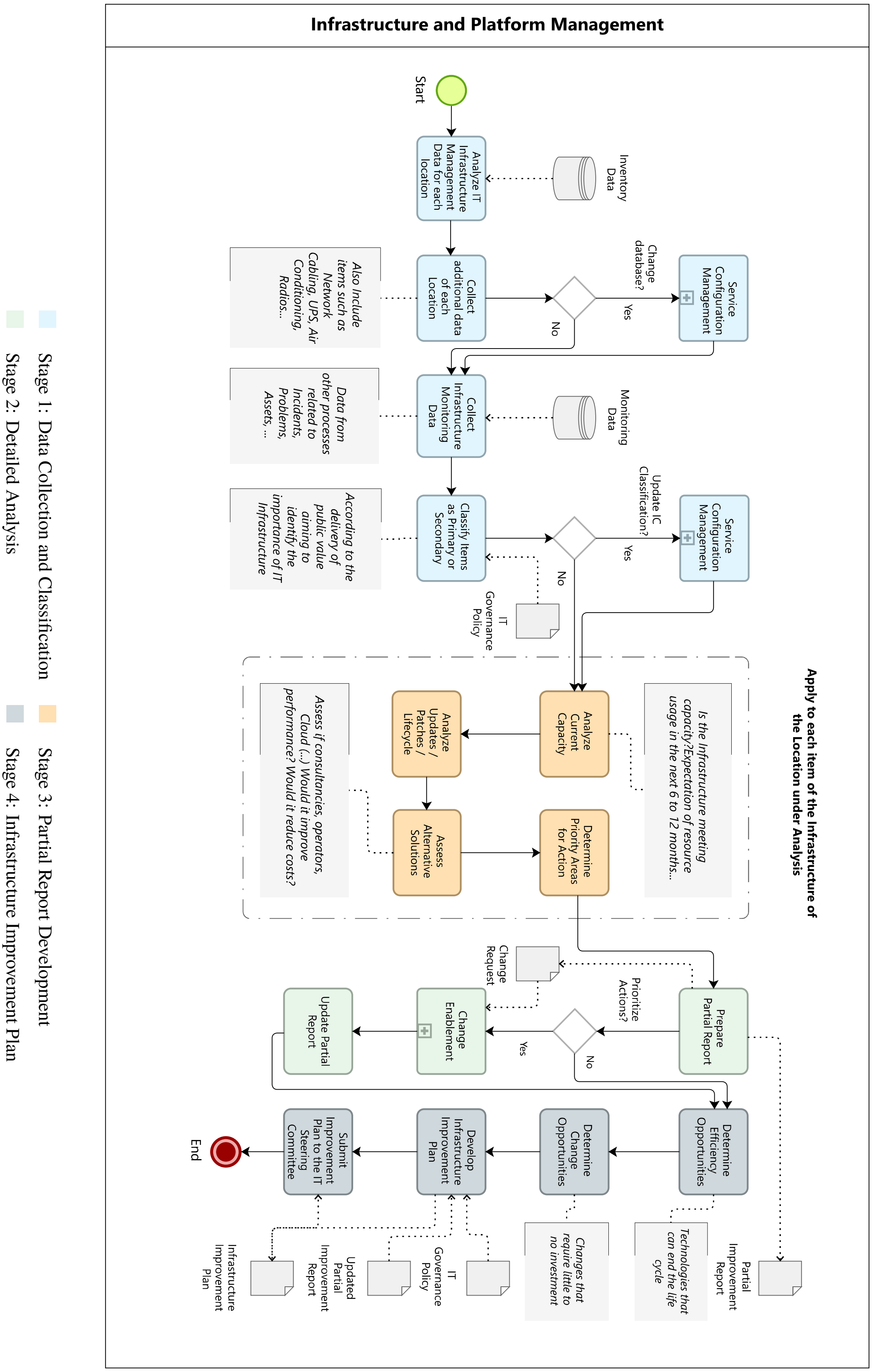

Figure 2. BPMN representation of the proposed ICT Infrastructure and Platform Management process (structure unchanged; extended operational detailing and pilot execution discussed in this study).

model adopts a granular approach, examining every location individually to allow a precise understanding of the operational environment and its contribution to the overall infrastructure. Existing inventory records are collected, complemented by on-site inspections to validate physical conditions, identify undocumented elements, and verify consistency with official asset databases.

Each Configuration Item (CI) is classified according to its direct contribution to public value delivery. Whenever discrepancies are found between documented data and the actual environment, they must be corrected through the Service Configuration Management practice, ensuring that records remain reliable for subsequent analytical stages. Table 2 summarizes the internal structure of this stage.

Table 2. Data Collection and Classification Stage

Element	Description
Inputs	Existing inventories, asset reports, network diagrams, monitoring data, and on-site inspections.
Activities	Identify CIs, verify physical conditions, classify items according to public value delivery, and detect inconsistencies.
Executors	Infrastructure team, support analysts, monitoring operators.
Outputs	Updated CI list, preliminary classification, identification of gaps.
Resources	Asset management records, scanning tools, monitoring platform, field checklists.

4.1.2 *Detailed Analysis, Prioritisation, and Alternatives*

Based on the information collected in the previous stage, the model guides a detailed evaluation of all identified CIs. Each item is assessed with regard to operational capacity, update status, redundancy, and availability of viable alternatives. This stage verifies whether the current configuration supports expected service demand and whether risks or technical constraints require intervention.

Prioritisation is performed using the GUT Matrix, which assigns numerical values to severity, urgency, and trend. This enables a structured ranking of actions and prevents decisions based solely on subjective perceptions or isolated demands. Table 3 presents the activities associated with this stage.

Table 3. Detailed Analysis, Prioritisation, and Alternatives

Element	Description
Inputs	CI list from the previous stage, monitoring indicators, documentation, and technical constraints.
Activities	Evaluate operational conditions, capacity, redundancy, update status, and risks; analyse alternatives; apply the GUT Matrix for prioritisation.
Executors	Infrastructure specialists, monitoring operators.
Outputs	Prioritised action list, updated technical assessment for each CI.
Resources	Monitoring tools and logs, documentation, GUT Matrix template.

4.1.3 *Partial Report Development*

This stage consolidates all information gathered and analysed so far into a partial report. The document records the current condition of the infrastructure, identifies incidents requiring immediate attention, and describes corrective actions. It synthesises the prioritisation of CIs, highlighting items that require investment, upgrade, or replacement.

The partial report serves as a direct input for CE practice, Risk Management, Asset Management, and ICT investment planning. It enables structured decision making based on objective evidence. When urgent corrections are performed during the analysis stage, the report must also document the change records generated by the CE practice or any equivalent local mechanism. Table 4 presents the structure of this stage.

Table 4. Partial Report Development

Element	Description
Inputs	Prioritised findings, CI assessments, urgent issues identified.
Activities	Consolidate data; document incidents requiring immediate action; trigger CE practice when necessary.
Executors	ICT infrastructure team, ICT management.
Outputs	Partial report, urgent intervention list, change records.
Resources	CE practice forms, reporting templates, logs.

4.1.4 *Infrastructure Improvement Plan Development*

Based on the updated partial report, this stage identifies opportunities for efficiency and targeted improvements in the ICT infrastructure. Using the compiled data and existing ICT governance policies, the Infrastructure Improvement Plan is prepared, listing recommended interventions, expected impacts, and required resources.

This stage finalises the technical cycle of the model. The plan is formally submitted to the ICT Steering Committee for analysis, validation, and deliberation, ensuring that the proposed actions align with institutional priorities, financial feasibility, and strategic objectives. Table 5 describes the activities associated with this stage.

Table 5. Infrastructure Improvement Plan Development

Element	Description
Inputs	Updated partial report, ICT policies, strategic goals.
Activities	Identify improvement opportunities; define actions; prepare the improvement plan; submit it to the ICT Steering Committee.
Executors	ICT management, infrastructure lead, governance representatives.
Outputs	Infrastructure Improvement Plan, implementation roadmap.
Resources	ICT governance policies, budget constraints, procurement rules.

4.2 Additional Components of the Model

In addition, the model incorporates complementary components that support both the initial operationalisation of the BPMN workflow and the consolidation of process maturity. These elements help structure early decisions, organise the supporting artefacts required during execution, and indicate the expected evolution at each maturity cycle.

4.2.1 Maturity Levels and Expected Situations

The identification of maturity levels represents a key stage prior to the effective application of the proposed model, as it allows the current state of IPM practices to be understood in relation to their organisation, control, and operational consistency over time.

This assessment enables managers to recognise how infrastructure activities are currently conducted and to identify which aspects require adjustment in order to reach more advanced stages of process development. It also provides a baseline reference for future comparisons, allowing the effects of the model implementation to be objectively analysed over successive cycles.

Based on the GAIA maturity model [Ueno, 2019], five levels were defined and adapted to the specificities of municipal public administration. These levels range from the absence of formal records and systematic control to full integration with governance and continual improvement mechanisms.

Level 1 – Reactive and Unstructured Infrastructure management is predominantly ad hoc and reactive. Assets are installed and configured without formal documentation, centralised records, or clear traceability. Responsibilities are loosely defined, and there is limited knowledge about the installed components, their purpose, or those responsible for their maintenance.

Level 2 – Partially Managed This level is characterised by partial and informal records of infrastructure elements. Although initial attempts at control may exist, they lack standardised documentation, defined procedures, or centralised organisation. Maintenance and recovery actions remain unstructured, with limited strategic awareness overall relevance.

Level 3 – Managed Significant progress becomes visible at this stage. A partially updated and centralised baseline exists, and infrastructure items with higher operational impact are identified and monitored. Responsibilities begin to be formally assigned, and maintenance procedures show initial signs of standardisation, although integration with governance and broader institutional strategies remains limited.

Level 4 – Managed and Auditable At this level, asset documentation is comprehensive, regularly updated, and auditable. Infrastructure monitoring is supported by appropriate tools, and change records become mandatory. Processes are formally integrated with ICT governance, and continuity and recovery procedures are documented and periodically reviewed.

Level 5 – Continual Improvement This level reflects a scenario of systematic review and evolution. Processes are continuously evaluated and updated based on performance indicators, lessons learned, and structured feedback. Infrastructure management becomes fully aligned with institutional strategies, and public value guides asset classification and prioritisation, reinforcing a cycle of progressive organisational learning and adaptation.

In practical terms, the transition between these levels reflects not only technical evolution but also changes in institutional behaviour. Moving from Level 1 to Level 3 indicates a shift from fragmented control to a minimally structured environment where infrastructure becomes visible and manageable. Reaching Levels 4 and 5 indicates the municipality's capacity to anticipate failures, support planning with consistent data, and sustain predictable cycles of review and continual improvement.

Table 6. Example of Asset Maturity Level

Level	Expected Situation
Level 1	No control or inventory of ICT assets.
Level 2	Some assets are recorded, but without standardised structure or centralisation.
Level 3	A formal and partially updated inventory exists.
Level 4	Asset management is systematic, auditable, and regularly monitored.
Level 5	Asset management is strategic, integrated with governance, with full traceability and use of indicators.

Table 6 illustrates how maturity levels are expressed for the asset management axis. Equivalent descriptions were defined for the remaining IPM axes and are available as supplementary material, preserving consistency across all dimensions evaluated.

4.2.2 Pre-Implementation Requirements

The effective execution of the proposed IPM model can be strengthened by meeting a set of desirable requirements and strategic support actions. These elements do not represent strict preconditions for the initial application of the model, but rather act as facilitators that tend to accelerate the evolution of organisational maturity across successive cycles. In accordance with the ITIL 4 principle *"Start where you are"* [AXELOS, 2019], it is recommended that the organisation operate based on its existing structure and progressively adapt its practices as its operational capacity evolves.

One of the primary aspects to be considered is the current state of asset control. Ideally, the inventory should reflect the real infrastructure environment as accurately as possible. However, gaps or inconsistencies in asset records do not prevent the application of the model and may be addressed in parallel with the first execution of the model, which itself contributes to improving data quality and consistency.

Another relevant element is the existence of structured CE practices. These facilitate the registration, approval, and traceability of modifications to the ICT infrastructure. When such processes are not formally established, a simplified protocol capable of recording significant changes and clearly informing stakeholders about planned interventions is considered sufficient for the initial stages.

The maturity level of the organisation also influences the complexity and depth of the actions that can be performed. Certain activities, such as vulnerability testing or the proposal of structural improvements, may require a higher degree of governance organisation. Nevertheless, the absence of advanced practices does not hinder the application of the model, reinforcing the importance of starting from the current scenario and pursuing gradual evolution.

Alignment with the ICT Steering Committee is also essential, as it contributes to the institutional legitimacy of the model and the feasibility of the proposed Infrastructure Improvement Plans. The workflow and its objectives should be formally presented to the committee, establishing commitments for periodic analysis and decision-making.

Finally, identified nonconformities should be assessed based on their impact and urgency. Situations that compromise services with higher operational impact must be prioritised through CE practice, particularly when classified as emergency changes.

Other demands should be forwarded to the Project Management process for structured evaluation, prioritisation, and potential inclusion in the organisation's Project Portfolio, ensuring an orderly and sustainable implementation path.

4.2.3 Environmental Support and Preparation

In addition to the desirable pre-implementation requirements, a set of practical actions can facilitate the preparation of the environment and support more effective execution of the proposed workflow. These actions do not constitute formal prerequisites, but rather operational enablers that improve visibility, data reliability, and consistency during the initial application of the model.

Monitoring mechanisms play a relevant role in this context, as they provide greater insight into the operational behaviour of infrastructure assets. Basic network scanning tools can assist in identifying devices present in each unit and in comparing real conditions with existing records.

Continuous monitoring solutions, such as Zabbix[4], enable the observation of performance, availability, and event patterns, supporting more informed analysis of failures and capacity constraints. Log analysis platforms may also contribute to the centralisation and interpretation of event records generated by systems and network devices.

Existing documentation represents another important resource. Physical and logical network diagrams, even when outdated, can serve as a starting point for organising technical records. The adoption of version control mechanisms contributes to more systematic documentation of procedures, configurations, and technical guidelines related to cabling, connectivity, power systems, and network security.

It is also advisable to align infrastructure records with public asset management information, ensuring coherence between operational reality and official patrimonial databases. Data provided by the asset management department should be cross-checked with local technical controls maintained by the ICT team, and necessary updates should be communicated and coordinated with the responsible sectors.

With regard to human resources, the mobilisation of the technical team must consider existing staffing constraints. Targeted training programmes for support professionals may enable them to perform tasks such as data collection and inventory validation, while more specialised personnel focus on activities requiring advanced technical expertise.

Finally, the potential adoption of ITSM tools, such as GLPI[5], may support the structuring of inventories, incident records, and CE practice. These systems facilitate the creation and maintenance of a Configuration Management Database (CMDB), consolidating information about CIs and their interrelationships. Although not mandatory, their use contributes to greater integration and traceability across infrastructure management practices.

4.2.4 Continual Improvement Integrated into the Model

The model incorporates a continual improvement cycle grounded in the logic used for maturity assessment. The first application of the QAD establishes a baseline that represents the current state of IPM. Based on this baseline, clear improvement goals are defined to support progression to the next maturity level in each axis. Actions are then planned considering both internal activities derived from the workflow and external initiatives, such as training or infrastructure upgrades. Figure 3 illustrates this cycle.

Strategic Vision and Baseline Definition. The cycle begins with the definition of a strategic vision aligned with public value objectives. This vision guides infrastructure management priorities and provides direction for improvement efforts. The initial application of the QAD establishes a baseline diagnosis, enabling the identification of current maturity levels across the model axes.

Assessment and Goal Definition. Based on the diagnostic results, maturity gaps are identified and translated into clear improvement goals. These goals define the intended progression toward the next maturity level and serve as reference points for planning and evaluation, ensuring that improvement efforts are realistic, measurable, and grounded in the assessed context.

Action Planning and Implementation. The defined goals are operationalised through action planning, which integrates internal activities specified in the BPMN workflow with complementary initiatives such as training, acquisitions, or technical partnerships. These actions are then implemented within the Infrastructure and Platform Management process, supported by monitoring and systematic recording of activities.

Evaluation and Consolidation. After execution, the QAD is reapplied to evaluate the effects of the implemented actions. The comparison between assessment cycles enables progress toward the defined goals to be measured and remaining gaps to be identified. Achieved improvements are consolidated through documentation, process formalisation, and communication to stakeholders, supporting organisational learning and feeding subsequent improvement cycles.

Beyond its operational role, the continual improvement cycle positions the model as a structured mechanism for organisational learning within ICT infrastructure management. Rather than functioning solely as a measurement routine, the cycle supports a logic of progressive transformation, in which diagnosis, goal definition, planning, execution, and reassessment are systematically articulated.

From this perspective, maturity is treated as a trajectory that can be monitored and adjusted over time, guiding the controlled and coherent evolution of infrastructure management practices across successive applications of the model.

[4] Zabbix, developed by Zabbix LLC, is an open-source platform for monitoring networks, servers, applications, and services. It offers functionalities such as performance metric collection, fault detection, alert generation, and customisable dashboards. Available at: https://www.zabbix.com. Accessed on 22 January 2026.

[5] GLPI (*Gestionnaire Libre de Parc Informatique*) is an open-source ITSM solution that provides functionalities such as asset inventory, incident management, service requests, change and problem management, and a knowledge base. Available at: https://glpi-project.org. Accessed on 22 January 2026.

The complete cycle diagram is available as supplementary material for further consultation.

Baseline Dimensions Supporting the Evolution of the IPM Practice

The maturity assessment applied before execution of the model is structured around eight dimensions that represent structural aspects influencing the evolution of the IPM practice. These dimensions do not replace the workflow, nor do they evaluate the model itself; instead, they indicate the organisational conditions that shape the pace and consistency of improvement across cycles.

ICT Assets This dimension assesses the degree of control, organisation, and traceability of technological resources such as servers, network equipment, systems, and licenses. It verifies whether assets are recorded, updated, and systematically managed to support availability and integrity. In ITIL 4, Asset Management covers the full life cycle of these resources, while Service Configuration Management treats them as CIs and maintains their relationships and dependencies.

Monitoring This dimension examines the practices used to supervise service and infrastructure performance, including the use of tools, event detection, baseline creation, and visibility into failures. ITIL 4 emphasises systematic observation and event management to detect changes in operational status, while frameworks such as COBIT provide complementary guidance for monitoring and control.

ICT Management Practices This dimension evaluates the degree of formalisation and integration of routines related to incident handling, CE practice, capacity supervision, and documentation. It considers whether processes are established, regularly updated, aligned with ITIL 4, and supported by indicators. The dimension reflects how well infrastructure routines respond to digital transformation and organisational needs within the organisation.

Strategic Alignment This dimension assesses how infrastructure actions and investments align with institutional objectives, ensuring that ICT decisions support organisational priorities. In ITIL 4, this alignment is reinforced by the Service Value System and its guiding principles, while public governance frameworks emphasise adherence to planning instruments and strategic directives.

Continual Improvement This dimension verifies the presence of mechanisms for collecting feedback, analysing indicators, documenting lessons learned, and updating procedures. ITIL 4 incorporates continual improvement as a core organisational activity, applied across all levels and processes.

People Management This dimension addresses the definition of responsibilities, development of competencies, and qualification of the teams involved in infrastructure activities. ITIL 4's Workforce and Talent Management practice highlights the need for adequate skills, role clarity, and long-term development, while frameworks such as COBIT reinforce the importance of competent human resources in achieving organisational objectives.

Risk Management This dimension examines how operational risks affecting infrastructure are identified, recorded, monitored, and treated. It considers the existence of policies, thresholds, and mitigation plans. In ITIL 4, risk is understood as a potential event that may affect objectives, and governance frameworks emphasise the need for clear definitions of acceptable risk and structured handling of threats.

ICT Security This dimension evaluates controls and practices aimed at protecting information and infrastructure from threats and unauthorised access, including policies, awareness actions, audits, and contingency mechanisms. Security covers confidentiality, integrity, availability, authentication, and non-repudiation, and involves both preventive and reactive actions aligned with institutional governance.

Together, these dimensions support the evolution logic of the proposed maturity maps, helping organisations identify structural conditions that enable consistent progression between levels. They also guide the definition of improvement goals aligned with the continual improvement cycle.

4.2.5 Evolution Map of the Maturity Axes

The evolution of the maturity axes occurs through internal workflow-linked actions and external suggestions that support the transition between levels. From Level 1 to Level 2, the focus is on organising data, classifying assets, and registering information in a systematic way (Table 7). From Level 2 to Level 3, the emphasis shifts to minimal process formalisation, periodic documentation, and the adoption of basic operational tools (Table 8).

From Level 3 to Level 4, maturity advances through consolidation of routines, standardisation of procedures, expanded monitoring, and stronger cross-sector coordination. At this stage, operational indicators begin to appear, verification routines become more structured, and records become more complete and consistent (Table 9).

Progressing to Levels 4 and 5 requires deeper integration with governance structures, the systematic use of indicators, regular audits, and explicit incorporation of the continual improvement cycle. The model supports this evolution by linking each axis to specific workflow activities, clarifying the internal actions required to sustain progression and showing how external initiatives can accelerate development.

The complete evolution maps for all axes and levels, including the transition from Level 4 to Level 5, are available as supplementary material to support reuse of the model, adaptation to different administrative contexts, and detailed analysis of each axis.

It is important to note that these recommendations are not prescriptive or definitive solutions. They represent examples of potential improvement actions, which each administration may adjust to realistic and achievable conditions in accordance with its structure, resources, and priorities, as reinforced by the Continual Improvement Cycle.

4.3 Execution of the Model in the Pilot Unit

To initiate execution of the model, a sector-based approach was adopted in a municipal administration classified as a large-sized city in Southern Brazil. A unit belonging to the municipal health network was selected due to the diversity of its services and the intermediate complexity of its ICT infrastructure. The health network comprises primary and

Figure 3. Continual improvement cycle integrated into the proposed ICT infrastructure and platform management model.

specialised care, operates multiple interconnected buildings, and supports a high volume of citizen demand, providing a representative scenario for evaluating infrastructure management practices.

The selected unit includes outpatient activities, specialised services, pharmaceutical dispensing, and support for emergency medical transport. Its physical structure contains distributed network segments connected to a central equipment room, combining legacy devices and recently installed components. This environment presents challenges commonly found in municipal ICT infrastructures, such as heterogeneous equipment, partial documentation, and operational dependencies not formally registered.

Execution followed the steps defined in the workflow, beginning with the analysis of ICT infrastructure data. This included reviewing municipal asset control records, partial inventory data available through the GLPI implementation, and information from monitoring platforms. The unit's network topology was validated through field inspections, which also identified undocumented elements such as equipment rooms, racks, brackets, air-conditioning systems, hermetic boxes, radio towers, and dedicated power panels. As an example of the core of this environment, Fig. 4 shows the main switches and the Optical Line Terminal (OLT) installed in the equipment rack.

Local network scans were performed to detect infrastructure devices, including automatic discovery via proprietary protocols, complemented by spreadsheets, network maps, and data retrieved from the monitoring server. Additional findings revealed the presence of standardised but non-structured cabling and incomplete documentation of deployments. Fig. 5 illustrates the DIO[6] identified during the inspections, while Fig. 6 shows one of the internal horizontal brackets.

During the monitoring stage, recent device information was collected from the Zabbix server, along with alert logs from the logging server and data from the OLT management interface. Historical bandwidth consumption was also analysed to identify congestion points and performance inconsistencies. The fieldwork also revealed external elements relevant to infrastructure continuity, such as the hermetic box with equipment supporting the distribution tower (Fig. 7) and the tower itself, which contains the access points used for inter-building connectivity (Fig. 8).

Figure 4. Core switches and OLT installed in the equipment rack.

[6]DIO stands for Internal Optical Distribution Frame (acronym in Portuguese: *Distribuidor Interno Óptico*, DIO).

Table 7. Example of Full Action Map from Level 1 to Level 2

IPM Axis	Internal Actions (BPMN Flow)	External Suggestions
ICT Assets	Collect inventory data of CIs (items 1.1 and 1.2); classify assets based on criticality or public value delivery (item 1.5).	Introductory training in asset inventory, lifecycle, and traceability; training in Assets vs. CIs.
Monitoring	Collect basic and manual data about failures and performance; identify simple tools to visualise the network; build a baseline to support item 1.4 of the flow.	Basic training in infrastructure monitoring and failure logging.
ICT Management Practices	Identify informal practices such as incident and change handling; record critical occurrences in the partial report.	Introductory training in ITIL 4; drafting simple flows for essential processes.
Strategic Alignment	Recognise from the BPMN flow that strategic alignment is central to elements such as the ICT Governance Policy and Improvement Plans.	Hold informal meetings to raise managerial awareness.
Continual Improvement	Carry out reactive actions with initial documentation.	Basic training in continual improvement concepts.
People Management	Informally assign responsibilities for basic infrastructure tasks.	Introductory workshop on defining responsibilities.
Risk Management	Identify basic operational risks linked to critical assets and begin documenting them.	Introductory training in recognising and documenting risks.
ICT Security	Apply basic and punctual security measures.	Basic training in ICT security good practices.

Figure 5. Internal Optical Distribution Frame (DIO).

Based on this dataset, subsequent steps of the model were executed, including classification of CIs, assessment of the operational capacity of each asset, verification of pending updates, identification of alternative solutions, and prioritisation using the GUT Matrix.

The pilot execution demonstrated that the proposed flow operates correctly in a real municipal environment and exposes issues that typically remain unnoticed during routine activities. It forced the identification of CIs, revealed undocumented dependencies, and clarified responsibilities that were previously dispersed across sectors.

Figure 6. Horizontal Cabling Bracket.

Figure 7. Hermetic box with equipment supporting the distribution tower.

The pilot also showed that the necessary adjustments could be carried out with the current staff and existing infrastructure components, without hiring new personnel or acquiring new equipment. Larger restructuring needs were prioritised and should be forwarded to the project portfolio for structured evaluation and future implementation. These results justify scaling the model to other units and indicate that the next implementation cycle will begin from a clearer and better-controlled baseline. Considerations and results derived from this analysis are presented in the next section.

5 Results Discussion

The first analytical step, focused on classifying CIs as primary or secondary, was shown to be applicable in the municipal context. The exercise resulted in 19 primary CIs and 15 secondary ones, demonstrating that the model's classification can be executed within municipal operational constraints. Beyond its descriptive role, the classification supported more structured analysis by avoiding premature investment considerations, such as replacing Category 5e cables with Category 6

Table 8. Example of Maturity Evolution from Level 2 to Level 3

IPM Axis	Internal Actions (BPMN Flow)	External Suggestions
ICT Assets	Implement a centralised inventory aligned with BPMN steps 1.1 and 1.2; initiate continuous updates; adopt a basic tool for asset and CI registration.	Training in GLPI or similar tools.
Monitoring	Register availability and failure data systematically; formalise periodic reports; implement simple log-collection tools.	Introductory training in Zabbix or similar.
ICT Management Practices	Formalise at least two key processes (incidents and changes); define routines and maintain simple documentation.	Training in structuring ITIL 4-based ICT processes.
Strategic Alignment	Prepare the Partial Report (BPMN step 2.0) for the steering committee; align objectives with the municipal ICT plan.	Workshops for strategic alignment between ICT and management.
Continual Improvement	Apply the improvement cycle (steps 1–7); document actions and results.	training in continual improvement and PDCA methods.
People Management	Assign responsibilities for inventory and monitoring routines; document these roles.	Basic training for operational teams.
Risk Management	Formally identify risks in BPMN step 1.9; register essential risks; begin mitigation planning.	Introductory training in basic ICT risk management.
ICT Security	Apply BPMN step 1.7 (updates and patches); document minimum security procedures.	Introductory training in ICT security fundamentals.

Table 9. Example of Maturity Evolution from Level 3 to Level 4

IPM Axis	Internal Actions (BPMN Flow)	External Suggestions
ICT Assets	Integrate asset control with monitoring, planning, and CE practice; validate CI data periodically across systems.	Adopt full CMDB solutions and advanced CMDB training.
Monitoring	Integrate monitoring with operational routines and ICT strategic planning; define thresholds, alerts, and structured reporting.	Advanced training in Zabbix, or similar systems.
ICT Management Practices	Standardise processes; assign process owners; define indicators and maintain periodic reviews.	Training in ICT governance, service management, and continual improvement.
Strategic Alignment	Integrate strategic objectives into the planning cycle; formalise alignment structures between ICT and leadership.	Training in strategic planning for ICT.
Continual Improvement	Formalise improvement practices; document cycles; integrate regular evaluation and feedback loops.	Advanced training in improvement methodologies and organisational learning.
People Management	Implement structured training policies; define competence requirements; adopt knowledge retention procedures.	Advanced training programs and leadership courses.
Risk Management	Implement continuous risk monitoring; maintain a structured risk register; integrate risk analysis into planning and CE practice.	Training in risk assessment tools and methods.
ICT Security	Develop an ICT security policy; conduct internal audits; maintain compliance routines and vulnerability assessments.	Training in operational security, audits, and incident response.

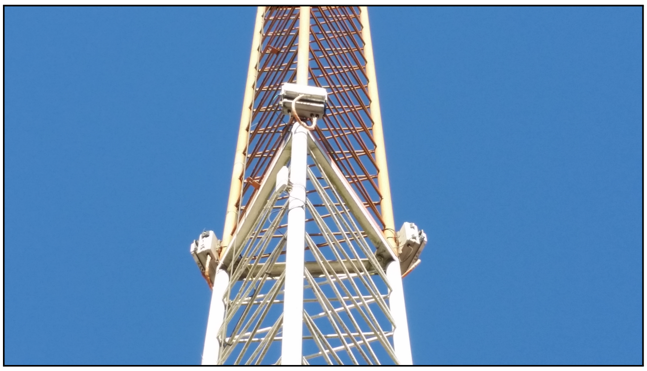

Figure 8. Partial view of the distribution tower with access points.

in points where the upgrade was not justified based on observed usage.[7]

Although Category 6 offers superior technical characteristics, replacing network cabling alone does not necessarily guarantee performance gains when data transmission volumes and connected equipment do not exploit the available capacity. In such cases, preventive maintenance, point scanning, and cable certification activities may identify degradation or failure points and provide objective evidence to support targeted replacements rather than blanket upgrades.

The use of Zabbix produced another relevant analytical effect. The inclusion of additional monitored items clarified recurring doubts about perceived network slowness and indicated that a significant portion of observed incidents originated outside the local infrastructure domain. This reinforces that expanded monitoring supports more accurate interpretation of infrastructure conditions and reduces the likelihood of decisions based solely on users' perceptions.

Verification of the CIs revealed devices configured with default SNMP communities, exposing security weaknesses that were not previously documented in available records.[8] The identification of this issue indicates that, even when applied in a limited pilot context, the model is capable of revealing operational vulnerabilities and supporting subsequent corrective actions related to security and control. In the same assessment, the identification of Small Office/Home Office (SOHO) devices acting as distribution equipment revealed additional risks and reinforced the need for gradual and planned changes.

The application of the GUT Matrix synthesised the findings, supported prioritisation, and informed proposals for future infrastructure adjustments. One representative example is the recommendation to deactivate external access points inherited from the *Cidade Digital* programme. The analysis showed that these devices do not meet current mobile device standards and generate radio spectrum competition, while the proposal to replace them with indoor Wi-Fi coverage follows directly from the model's prioritisation logic.

The pilot execution also identified situations that require formal handling through change processes, such as configuration adjustments and the disabling of endpoint functions that caused network interference. Actions that had previously been executed informally were identified, indicating the need for subsequent documentation and formal registration.

In addition to these operational observations, the pilot revealed structural requirements that exceed the scope of incremental interventions, such as the need for conditioned electrical power through Uninterruptible Power Supply (UPS) systems and, in later stages, a backup generator. These requirements do not represent achieved improvements, but rather inputs for the project portfolio, as they involve significant investment and depend on areas outside the ICT domain. In this context, monitoring records provide objective technical evidence to support future justification and prioritisation decisions in subsequent planning cycles.

Table 10. Infrastructure items and classification in the pilot units

Unit	Item	Classification
Med. Center	Bracket 01	Secondary
Med. Center	UTP cabling	Secondary
Med. Center	24p edge switch	Primary
Med. Center	Bracket 02	Secondary
Med. Center	24p edge switch	Primary
Med. Center	DVR recorder	Secondary
Dental Unit	Bracket 03	Secondary
Dental Unit	24p edge switch	Primary
Dental Unit	UTP cabling	Secondary
24h Unit	Equipment room	Secondary
24h Unit	Rack 01	Secondary
24h Unit	Distribution switch A	Primary
24h Unit	Distribution switch B	Primary
24h Unit	OLT	Primary
24h Unit	UPS 3 kVA (1)	Primary
24h Unit	UPS 3 kVA (2)	Primary
24h Unit	Optical infrastructure	Secondary
24h Unit	Power panel 01	Secondary
24h Unit	UTP cabling	Secondary
24h Unit	Air-conditioning	Secondary
Pharmacy	Bracket 04	Secondary
Pharmacy	16p edge switch	Primary
Ambulances	16p SOHO switch	Primary
Ambulances	Bracket 05	Secondary

In summary, the pilot results indicate that the proposed model is feasible within the municipal environment and can be applied under real operational conditions. The experience at the Health Complex suggests that, if applied systematically across successive cycles, the model may support the consolidation of routines, more consistent analytical practices, and more informed decision-making. These observations should be interpreted strictly as evidence of feasibility and initial demonstration. Any effects related to efficiency gains, service quality improvement, or value delivery remain hypotheses to be evaluated through full implementation and subsequent quantitative assessment.

[7] Category 5e cabling was standardised in 2001 as an enhanced version of Category 5, supporting transmission speeds of up to 1 Gbps over distances of up to 100 metres. Category 6, standardised in 2002, supports higher bandwidth (up to 250 MHz), improved crosstalk isolation, and stricter electrical performance requirements, allowing transmission speeds of up to 10 Gbps over shorter distances. These characteristics make Category 6 more suitable for modern network environments with higher traffic density and electromagnetic interference, according to ANSI/TIA-568 and ISO/IEC 11801 standards ANSI/TIA [2018]; ISO/IEC [2017].

[8] Simple Network Management Protocol (SNMP) is a standard network management protocol used to monitor and configure network devices. Default community strings are widely known and, if not changed, may allow unauthorised access to device information or configuration parameters [Harrington *et al.*, 2002].

As shown in Tables 10 and 11, the pilot classified key infrastructure CIs according to their relevance for service delivery.

Table 11. Tower infrastructure items and classification in the pilot network segment

Unit	Item	Classification
Tower	40 m tower	Primary
Tower	Hermetic box	Secondary
Tower	16p fabric switch	Primary
Tower	Link radio (South)	Primary
Tower	Link radio (Rural)	Primary
Tower	Link radio (Baroneza)	Primary
Tower	AP + PoE supply	Primary
Tower	AP + PoE supply	Primary
Tower	AP + PoE supply	Primary
Tower	UPS 600 VA	Primary

6 Research Ethics

This study was conducted in accordance with ethical principles applicable to research in the social sciences and public administration context. The research involved the application of a maturity assessment questionnaire to ICT professionals working in a municipal public administration, focusing on organisational processes and infrastructure management practices.

Participation was voluntary, and respondents were informed about the objectives of the study, the nature of the questions, and the use of the collected data for academic purposes. No personally identifiable information was collected, and all responses were analysed in an aggregated manner, ensuring anonymity and confidentiality.

The study did not involve vulnerable populations, clinical procedures, or interventions that could result in physical, psychological, or social risks. In accordance with Brazilian regulations, particularly Resolution CNS nº 510/2016, which governs research in the humanities and social sciences, the study does not require formal approval by a Research Ethics Committee, as it is limited to professional perceptions and organisational practices without individual identification.

Nevertheless, ethical care was observed throughout all stages of data collection, analysis, and reporting, ensuring transparency, respect for participants, and responsible handling of information.

7 Conclusion

This study investigated an approach aimed at improving the management of ICT infrastructure in municipal public administration, guided by the research question: *"How can the development of an infrastructure management model based on ITIL 4 practices provide structural support aimed at improving efficiency, quality, and value delivery of ICT services in municipal public administration?"*

The initial hypothesis assumed that the adoption of a structured flow aligned with recognised practices could offer managers a clearer view of the existing infrastructure, increase control over assets, and support decision-making processes related to the expansion and maintenance of ICT services, potentially contributing to improved public service delivery.

The proposed work resulted in the construction of an ICT Infrastructure Management model based on the ITIL 4 Infrastructure and Platform Management (IPM) practice and structured according to the Design Science Research (DSR) approach. The artefact follows an adaptive and realistic logic, grounded in progressive evolution through maturity cycles. The inclusion of the tailoring concept strengthens the model's applicability across different contexts within public administration, considering variations in size, structure, resources, and maturity levels.

This approach is intended to address challenges related to the generalisation and scalability of solutions in the public sector. Although the ITIL 4 IPM practice can be customised and applied directly in private-sector environments, the structure presented here suggests a practical path for implementation in such contexts as well, particularly when tailoring is adopted. The alignment between the notion of public value in government and customer value in private organisations enables ICT infrastructure to be oriented toward value generation in different domains, while maintaining coherence with consolidated theoretical foundations.

The model was subjected to an initial assessment through a maturity diagnostic questionnaire [Galian *et al.*, 2025] and subsequently through an initial implementation in a municipal public administration health complex. Although the maturity level identified in the diagnostic phase was below the desired level, the first execution cycle was completed successfully, supported by the technical team's experience, the existence of previous mappings, and a minimally organised resource structure. From a feasibility and initial demonstration perspective, the first iteration indicated that once the model is initiated, it generates inputs that may facilitate subsequent cycles.

This observation is relevant for organisations that may perceive the process as complex or time-consuming, as the initial implementation tends to require greater effort depending on the institution's maturity level, while later iterations are expected to become more fluid as they build upon previously generated outputs.

In summary, this paper reports a feasibility study and an initial demonstration of an ICT infrastructure management model tailored to the context of municipal public administration. The results indicate that the proposed model provides structural support for organising infrastructure-related activities and for guiding decision-making processes aligned with value-oriented objectives. As an interim evaluation, the findings should be interpreted as evidence of applicability and practical viability, rather than as a definitive measurement of impact on efficiency, quality, or value delivery.

8 Future Work

Future work will focus on extending the application of the proposed model to additional organisational units within municipal public administration, enabling a more robust and quantitative evaluation of its effects across successive maturity cycles. As the model is scaled, new maturity measurements will be collected to support comparative analysis over time.

In addition, the model may be evaluated in municipalities of different sizes, as well as in other public organisations, in order to examine its adaptability and the role of tailoring mechanisms embedded in the proposed process. Replication in diverse administrative settings can support external validation and enable the incremental refinement of the model, strengthening its applicability across different organisational contexts.

Further studies may also explore the integration of the proposed infrastructure management model with other ITIL 4 practices, such as Asset Management, Configuration Management, CE practice, and Information Security Management. This line of investigation may support a more comprehensive view of ICT governance and management, while preserving coherence with the value-oriented principles underpinning the model.

Declarations

Acknowledgements

During the preparation of this manuscript, the authors used the generative AI tool ChatGPT (OpenAI, GPT-5.1 model, accessed between August and September 2025) exclusively for grammatical and orthographic corrections and for support with English translation. The tool did not generate scientific ideas, structure arguments, produce literature reviews, or perform data analyses. All methodological decisions, interpretations, and conclusions were made by the authors. All content was critically reviewed by the authors prior to inclusion, and the use of the tool complies with the ethical and editorial guidelines of this journal. The authors remain fully responsible for the originality and integrity of this work.

Authors' Contributions

The authors' contributions, according to the CRediT taxonomy, areas as follows: Moisés de Sousa Galian contributed to Conceptualisation, Methodology, Formal analysis, Investigation, Data curation, and Writing the original draft. José Eduardo Santana contributed to conceptualisation and to Methodology, providing the theoretical basis on public value, its implications for ICT governance in the public sector, and insights on municipal public administration. Felipe Dias Abrahão contributed to Writing – review and editing, English translation support, and incorporated Smart Cities concepts. Vanessa Tavares de Oliveira Barros contributed to Methodology and to the design of the questionnaire, and acted in Co-supervision. Rodolfo Miranda de Barros contributed to conceptualisation, provided theoretical foundations on ICT governance, tailoring, and ITIL-related concepts, and acted in Supervision. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets, BPMN diagrams, supporting tables, and high-resolution figures of the model, as well as all complementary materials used or generated in this study, are openly available at the Zenodo repository (DOI: https://doi.org/10.5281/zenodo.18370189). The package also includes a step-by-step quick-start guide (README) and a filled example (including a completed prioritisation template) to support replication and practical adoption. The materials are organised into folders to facilitate navigation, reuse, and direct inspection of the workflow artefacts in BPMN-compatible tools. In addition, the repository provides practical files that allow readers to reproduce the prioritisation stage and understand the expected outputs of one execution cycle. This availability supports consultation, reproducibility, and the principles of open science and knowledge sharing.

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