

Article

Toward an Automated REOT: A Conceptual Planning Support System for Territorial Monitoring in Portugal

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Abstract

Territorial planning in Portugal requires the regular preparation of State of Territorial Planning Reports (REOT) to evaluate the implementation of spatial planning instruments. However, these reports are traditionally produced as static documents, limiting their effectiveness as decision-support tools. This paper proposes a conceptual framework for the dynamic generation of REOT through the integration of official spatial and administrative data within a Planning Support System (PSS). The proposed architecture combines rule-based logic, automated indicator calculation and interactive dashboards to support the on-demand production of continuously updated planning information while preserving the possibility of data aggregation and harmonisation at municipal, regional and national scales. To complement the conceptual framework, the paper presents the Cascais Experience, a pilot implementation developed within the Municipality of Cascais. Although not constituting a Dynamic REOT, the pilot demonstrates the feasibility of integrating municipal administrative data into a dynamic urban planning dashboard capable of automatically producing planning indicators and supporting on-demand monitoring. The experience also provides valuable insights into the practical challenges associated with data integration, information standardisation and indicator development. The framework is developed within the Portuguese legal and institutional context, recognising that current monitoring practices are implemented independently by each municipality, often using heterogeneous methodologies that hinder territorial comparability and multi-level analysis. The pilot implementation demonstrates that the principal barriers to dynamic territorial monitoring are organisational and informational rather than technological, highlighting the importance of data governance and administrative information management. The findings support the transition from episodic reporting towards continuous, data-driven territorial monitoring and provide a scalable framework for the future development of Dynamic REOT systems in Portugal and other planning contexts.

Keywords: Planning Support System; territorial monitoring; indicators; automated reports



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1. Introduction

Territorial planning is a fundamental instrument for promoting sustainable development, guiding land-use policies, coordinating public intervention, and supporting the efficient management of territorial resources. Over recent decades, the growing complexity of territorial systems, driven by urbanisation, demographic change, climate change, digital transformation, and increasing data availability, has reinforced the need for continuous territorial monitoring capable of supporting evidence-based planning and adaptive governance. Consequently, monitoring and evaluation have become integral components

of contemporary territorial planning systems, providing the information required to assess policy implementation, understand territorial dynamics, and support the continuous adaptation of planning strategies [1–5].

Within the public policy cycle, monitoring and evaluation perform distinct yet complementary functions. Monitoring provides continuous information on the implementation of policies and the evolution of territorial processes, whereas evaluation assesses the effectiveness, efficiency, and impacts of public interventions in relation to their intended objectives [6–13]. Together, these activities promote institutional learning, transparency, accountability, and informed decision-making. International organisations such as the European Commission, the OECD, and the United Nations have increasingly promoted harmonised monitoring methodologies, standardised indicators, and interoperable evaluation frameworks, recognising that comparable and continuously updated territorial information constitutes a prerequisite for effective territorial governance and sustainable development [1,10,14–20].

These developments are particularly relevant in territorial planning, where decision-making increasingly depends on the timely availability of reliable territorial information. Traditional monitoring approaches based on periodically updated reports frequently struggle to capture rapidly evolving territorial dynamics, creating a temporal gap between the actual state of the territory and the information available to decision-makers. This limitation reduces the capacity of planning systems to respond proactively to emerging territorial challenges and highlights the need for monitoring models capable of providing continuously updated evidence rather than isolated periodic assessments.

In Portugal, territorial governance is organised through the Territorial Management System (Sistema de Gestão Territorial Português—SGTP), within which the Municipal Master Plan (Plano Diretor Municipal—PDM) constitutes the principal municipal planning instrument. The State of Territorial Planning Report (Relatório de Estado do Ordenamento do Território—REOT), established under the Legal Framework for Territorial Management Instruments (RJIGT), represents the official instrument for monitoring territorial development and evaluating the implementation of territorial management instruments. The REOT synthesises territorial indicators, assesses the implementation of territorial public policies, and provides the technical basis for revising, amending, or updating territorial plans. Its primary purpose is therefore to support continuous territorial monitoring and evidence-based decision-making throughout the planning cycle [21].

Despite its strategic importance within the Portuguese territorial planning system, the REOT continues to be developed predominantly as a static document produced at predefined intervals through a dedicated process of data collection, statistical analysis, territorial assessment, and report preparation. Although this production model satisfies the formal legal requirement of periodically reporting on the state of territorial planning, it does not fully achieve the monitoring objectives that motivated the creation of the REOT. By the time the report is completed, much of the underlying information has already evolved, reducing its usefulness for supporting ongoing territorial management and adaptive planning. Consequently, the REOT often functions as a retrospective assessment of past territorial conditions rather than as an operational instrument for continuously monitoring the implementation and impacts of territorial public policies.

This paper argues that this limitation does not primarily result from the REOT itself but from the production paradigm through which it is currently implemented. Rather than viewing the REOT as a report that initiates a new process of data collection, analysis, and interpretation whenever its preparation is legally required, this study proposes a different conceptual perspective in which the REOT becomes the documentary output of a permanent territorial monitoring process. Under this approach, territorial information is

continuously collected, updated, and organised through a structured monitoring dashboard based on officially available datasets and a predefined framework of territorial indicators. Consequently, the production of the REOT no longer depends on initiating a new analytical process but simply on extracting an updated report that reflects the current state of territorial development at any given moment.

The proposed Dynamic REOT should therefore be understood not as a new territorial planning instrument, nor as a software application, an artificial intelligence system, or a new territorial indicator framework. Instead, it represents a methodological reconceptualisation of an existing statutory instrument, transforming the REOT from a periodically produced static report into the reporting output of an ongoing territorial monitoring process. The monitoring dashboard constitutes the operational environment through which territorial evidence is continuously maintained, while the REOT becomes an on-demand representation of that continuously updated knowledge. This conceptual shift aligns the production of the REOT with its original monitoring purpose and strengthens its role as an instrument supporting evidence-based territorial governance.

It is important to distinguish the proposed Dynamic REOT from the pilot implementation presented in this paper. Whereas the Dynamic REOT represents a comprehensive territorial monitoring framework encompassing multiple thematic domains required by Portuguese legislation, the Cascais Experience focuses exclusively on the urban planning management component. Its purpose is not to automatically generate a statutory REOT but to demonstrate that continuously updated municipal administrative data can support automated indicator production, interactive monitoring and on-demand reporting. As such, the pilot validates several fundamental components of the proposed conceptual framework while simultaneously identifying the practical challenges associated with its implementation. Although limited to the urban planning management domain, the pilot constitutes a proof of concept demonstrating that the proposed approach is operationally feasible and that its gradual extension to the complete REOT framework represents an organisational evolution rather than a technological leap.

To demonstrate the operational feasibility of this conceptual transformation, this paper proposes a standardized methodological framework describing how a Dynamic REOT may be implemented through the integration of official spatial and statistical datasets, interoperable territorial indicators, Geographic Information Systems (GIS), Planning Support Systems (PSS), and interactive monitoring dashboards. To complement this conceptual framework, the paper presents the Cascais Experience, a pilot implementation developed within the Municipality of Cascais. Although the pilot does not constitute a complete Dynamic REOT, it demonstrates the feasibility of integrating municipal administrative data into a dynamic urban planning dashboard capable of automatically producing planning indicators and supporting on-demand monitoring. The experience also provides empirical evidence regarding the organisational, methodological and technological requirements necessary for implementing continuous territorial monitoring systems, while highlighting that the principal implementation challenges are associated with data governance, information standardisation and administrative data quality rather than with software availability or computational capacity (Figure 1).

Accordingly, the contribution of this study is fourfold. From a theoretical perspective, it reconceptualises the role of the REOT within the Portuguese territorial planning system as an instrument of continuous monitoring rather than periodic reporting. From a methodological perspective, it proposes a standardized framework for organising territorial information, indicators and monitoring processes capable of supporting the dynamic production of REOTs. From an empirical perspective, it presents the Cascais Experience, a pilot implementation demonstrating the practical feasibility of integrating municipal

administrative data into a Planning Support System capable of producing continuously updated planning indicators. Finally, from an applied perspective, the lessons learned from the pilot identify the principal organisational, informational and governance challenges that must be addressed before a fully operational Dynamic REOT can be implemented across Portuguese municipalities. Collectively, these contributions provide a transferable framework for modernising territorial monitoring practices in Portugal while offering methodological insights applicable to other planning systems facing similar challenges in the transition from static reporting to continuous, data-driven territorial governance.

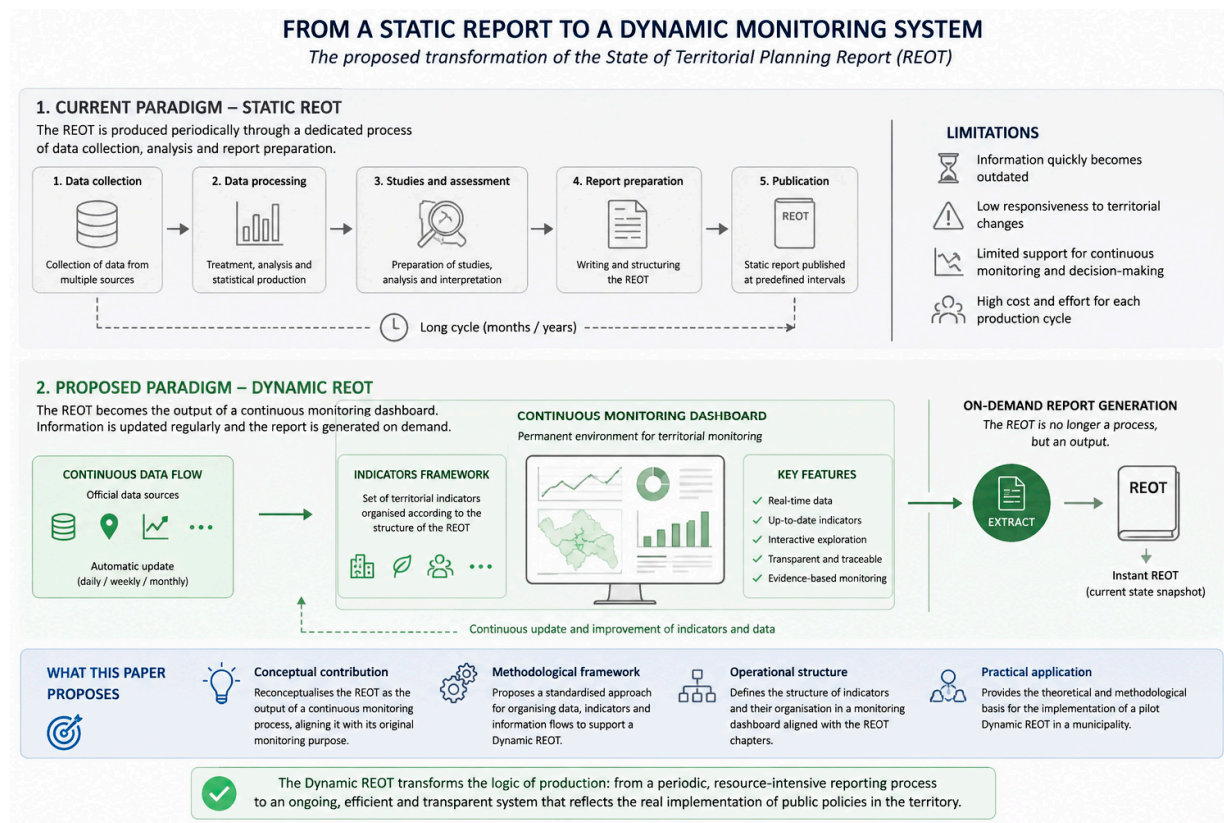


Figure 1. Conceptual framework proposed in this study.

2. Background

The technologies discussed in this section should be understood as representative examples of the current evolution of Planning Support Systems rather than as mandatory components of the proposed framework. The Dynamic REOT proposed in this paper is based primarily on standardized data integration, rule-based processing, and automated reporting. More advanced approaches, such as machine learning, predictive analytics, Digital Twins, and agentic AI, are discussed only as potential extensions that may enhance future implementations and therefore remain outside the scope of the framework proposed in this paper. The empirical contribution of this study focuses instead on demonstrating the feasibility of integrating municipal administrative data into a dynamic Planning Support System through the pilot implementation presented in Section 4.5.

Urban and territorial planning has been evolving rapidly and modernizing, particularly benefiting from technological advancements, notably through the integration of Machine Learning (ML) and Artificial Intelligence (AI) into decision-making processes. ML enables the analysis of complex territorial patterns, detection of emerging trends, optimization of land-use allocation, and simulation of development scenarios, supporting more informed and accurate decisions at municipal and regional scales. Complementarily, AI

approaches applied to dynamic planning, including agent-based frameworks (agentic AI), allow the continuous adaptation of territorial layouts and management of spatial units in a customized manner, fostering human–machine integration and faster, more robust decision-making in the face of territorial complexity.

Another relevant technological frontier lies in the use of Digital Twins and real-time monitoring, which allow the creation of digital replicas of cities and territories by integrating data from sensors, IoT, and official statistical sources. This approach enables continuous monitoring of territorial indicators and the simulation of “what-if” scenarios, enhancing the capacity to anticipate impacts before implementing policies or projects. The integration of automated spatial indicators, including deep neural networks and Graph Neural Networks, complements this process by allowing the automatic and multidimensional quantification and analysis of complex territorial information, supporting strategic decision-making, resource management, and public policy evaluation.

Finally, the evolution of Spatial Decision Support Systems (SDSS), combined with governmental innovation initiatives, territorial resilience, and governance, strengthens institutional capacity to manage, monitor, and evaluate public policies in a coordinated and intersectoral manner. These advances contribute to more adaptive, transparent, and evidence-based planning capable of responding to contemporary volatility, complexity, and unpredictability.

While these technological developments illustrate the evolution of contemporary Planning Support Systems, comparatively fewer studies have focused on the continuous integration of operational municipal administrative data to support statutory territorial monitoring. This distinction is particularly relevant in the Portuguese context, where the REOT is legally required and depends largely on information generated during the daily operation of municipal planning services. Consequently, the implementation challenges addressed in this paper are primarily related to data governance, information standardisation, administrative interoperability, and automated indicator production rather than predictive modelling or artificial intelligence.

Considering the discussion within the specific Portuguese context, with its particular scale, legislative architecture, regulatory framework, and the limitations of governmental structures responsible for executing the various tasks implicit in a monitoring and evaluation model, it is clear that Portugal presents a unique case. The challenges of integrating automated and dynamic Planning Support Systems (PSS) are amplified by the dispersed responsibilities, limited resources, and varying capacities at municipal, regional, and national levels [22]. While this context may be unique, it provides an opportunity to examine lessons from broader international experiences in urban and territorial planning evaluation and monitoring, keeping in mind the necessary caveats when considering transposition to the Portuguese Territorial Management System and its operational realities.

In this regard, several internationally recognized platforms offer valuable points of reference. CommunityViz, for instance, provides scenario planning tools that allow stakeholders to explore the consequences of land-use and policy decisions through interactive GIS-based simulations, emphasizing participatory decision-making. UrbanSim offers an integrated modeling platform that simulates urban development patterns and predicts impacts on housing, transportation, and land use, supporting evidence-based decision-making across multiple sectors and time horizons. Similarly, the What if? planning software allows real-time scenario modeling with a focus on sustainability, social impact, and stakeholder engagement, facilitating collaborative planning exercises that integrate environmental, economic, and social data layers.

Beyond software platforms, well-documented implementations of Planning Support Systems (PSS) in the Netherlands, Australia, and Scandinavia provide concrete examples

of how institutional frameworks, data governance, and technological infrastructure can be organized to support continuous territorial monitoring and evaluation. In the Netherlands, municipal-level PSS initiatives integrate GIS-based dashboards and participatory planning tools to coordinate land-use policies effectively. In Australia, state-level implementations emphasize cross-agency data sharing, real-time monitoring, and evidence-based evaluation of urban policies. Scandinavian countries, notably Sweden and Denmark, have developed PSS models that combine spatial decision support with strong institutional coordination, resilience-focused indicators, and open-data frameworks, demonstrating how automated monitoring and evaluation can be scaled across multi-level governance systems. These experiences offer important lessons for Portugal, highlighting best practices in system design, integration of dynamic dashboards, and alignment of technical tools with institutional capacities and legal frameworks.

Although these international experiences provide valuable methodological references, none was specifically designed to support the continuous production of a statutory territorial monitoring report equivalent to the Portuguese REOT. To complement the conceptual discussion presented in this paper, the Cascais Experience is introduced as a pilot implementation demonstrating that municipal administrative data can be integrated into a dynamic Planning Support System capable of automatically producing planning indicators and supporting on-demand monitoring. While not constituting a Dynamic REOT itself, the pilot validates several fundamental components of the proposed framework and highlights the organisational challenges associated with data quality, standardisation and historical information management.

Building on these international experiences, the implementation of a Dynamic REOT in Portugal can significantly enhance the territorialization of public policies. Land-use public policies have gradually evolved from centralized, restrictive, and minimally evidence-based decisions to more dynamic, inclusive, transparent, and integrated processes [23]. Despite advances in public participation, intersectoral collaboration, and consideration of territorial relevance, implementation challenges persist due to the diversity and specificity of local contexts [24,25]. Land-use policies are instruments that evolve over time, with their implementation playing a central role in territorial management and strategic planning [26]. Continuous evaluation and monitoring are fundamental to adapting policies to emerging challenges, ensuring their effectiveness, efficiency, and territorial coherence. Mechanisms for producing dynamic REOTs offer a competitive advantage over planning processes that rely on outdated information, allowing real-time adaptation and evidence-based decision-making.

Within the scope of this article, two complementary perspectives are therefore brought together. The first examines the evolution of monitoring and evaluation in territorial planning and the rationale for reconceptualising the Portuguese REOT as a continuously updated monitoring instrument. The second reviews the evolution of Planning Support Systems and discusses how existing technological approaches can support the implementation of such a system. These conceptual perspectives are subsequently complemented by the Cascais Experience pilot implementation, providing an empirical proof of concept that demonstrates the feasibility of integrating municipal administrative information into a dynamic monitoring dashboard capable of supporting future Dynamic REOT implementation.

2.1. Evolution of Evaluation in Territorial Planning and the Need for a Dynamic REOT

Evaluation in territorial planning has become an established institutional practice, based on impact analysis and the routine institutionalization of monitoring processes. This evolution reflects a shift from a compliance-focused approach to one centered on

implementation, emphasizing territorial dynamics, continuous learning, and progressive improvement of public policies [9,12,27–29].

Sectoral evaluations, targeting specific objectives and components of implementation, have increased the frequency and complexity of analyses, requiring specialized technical skills and the development of structured professional communities [13]. In Portugal, such communities are still not fully consolidated, particularly at the local level [3,22]. Currently, evaluation occurs at different stages of the planning cycle (ex-ante, ongoing, and ex-post) serving functions such as optimization, comparison, characterization, feasibility assessment, interpretation, and calculation of added value [30,31]. However, the lack of uniform rules, procedures, and indicators limits the ability to produce information that meets strategic needs, with state reports often focusing only on available data.

In this context, implementing a dynamic REOT emerges as a strategic solution. By integrating interactive dashboards and automated systems, harmonized at the national level, the REOT enables continuous monitoring of territorial public policy implementation, supporting adaptive, evidence-based decision-making. By connecting interrelated indicators, it also ensures that generated knowledge is transferable and comparable across territories, without compromising local specificities.

European and international influence further reinforces this approach. The European Union and other international organizations promote methodological harmonization, encouraging territorial comparisons, interterritorial learning, and dissemination of best practices [5,24,32]. Programs such as ESPON provide comparative databases, facilitate experience exchange, and strengthen the evaluation culture, enabling Member States to develop adaptive, coherent, and effective territorial policies [6]. This Europeanization of territorial planning highlights the importance of dynamic systems capable of combining continuous monitoring, systematic evaluation, and learning, without imposing rigid standardization that overlooks local contexts.

Therefore, the consolidation of a Dynamic REOT framework (Figure 2) not only modernizes territorial evaluation but also promotes coherence between policy and practice, enhancing decision-making capacity, institutional learning, and innovation at the territorial level. The pilot implementation presented later in this paper (Cascais Experience) illustrates that the technological foundations required for such a framework are already feasible using existing municipal administrative information, while simultaneously highlighting the organisational challenges associated with data governance and information standardisation.

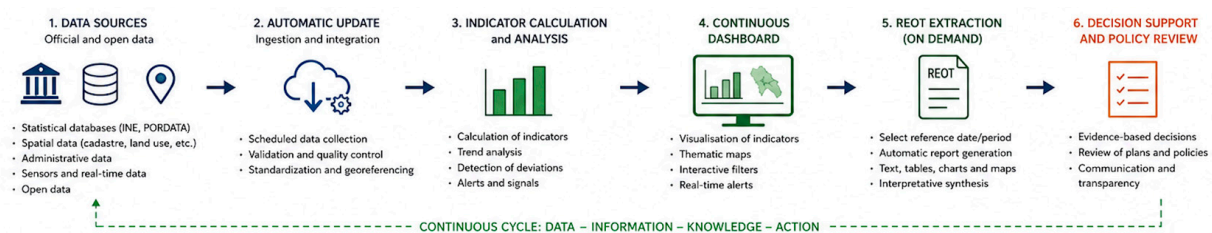


Figure 2. Dynamic REOT framework.

2.2. Planning Support Systems (PSS) and the Dynamic REOT

Planning Support Systems (PSS) are computational platforms that integrate spatial, statistical, and planning data, offering tools for analysis, simulation, and visualization to support decision-making [33,34]. These systems enable scenario exploration, assessment of potential impacts, and real-time monitoring of territorial trends, transforming territorial planning and public policy formulation from a reactive and episodic process into a proactive, evidence-based process. In Portugal, the adoption of PSS remains limited, despite its

potential to overcome the limitations of traditional instruments such as REOTs, which are static and updated sporadically across local, regional, and national scales [35,36]. Dynamic dashboards provide a solution to this limitation, enabling the continuous integration of administrative and territorial data and the generation of updated reports on demand. The Cascais Experience presented in Section 4.5 provides an initial demonstration of this approach through the implementation of a dynamic urban planning dashboard based on municipal administrative data.

The capabilities of PSS are further enhanced by Artificial Intelligence (AI), which expands their potential by automating structured, rule-based workflows such as indicator calculations, report generation, and territorial analysis [24,33]. AI also enables the management of agentic processes, characterized by complexity, uncertainty, and the need for contextual adaptation, in which agents—human or artificial—act intentionally, autonomously, and goal-oriented, making decisions, executing actions, and adjusting behavior based on feedback. Integrating PSS, dynamic dashboards, territorial indicators, and advanced AI is thus expected to: (a) overcome the static nature of REOTs; (b) automate indicator calculation and interpretation; (c) integrate official real-time data; (d) incorporate international and European best practices; (e) support multi-scalar, intersectoral, and adaptive decision-making; (f) consolidate evaluation as a continuous institutional culture; (g) enable management of complex, agentic processes through intelligent automation.

The combination of Planning Support Systems, automated indicator production, and interactive dashboards provides the technological foundation for the transition from a static, episodic model towards a dynamic, continuous, and adaptive territorial monitoring process. Artificial Intelligence represents an important opportunity for future developments, particularly regarding predictive analysis, automated interpretation and intelligent decision support. However, the Cascais Experience demonstrates that substantial improvements in territorial monitoring can already be achieved through the systematic integration of municipal administrative information, rule-based indicator calculation and business intelligence tools, without requiring advanced artificial intelligence techniques. Continuous monitoring, automated analysis and interactive dashboards therefore transform episodic reports into effective decision-support tools, improving reporting frequency, analytical depth and the overall usefulness of REOTs.

3. Institutional Context in Portugal

3.1. *The Role of the State of Territorial Planning Report (REOT)*

The State of Territorial Planning Report (REOT) is the statutory instrument established by the Portuguese Legal Framework for Territorial Management Instruments (RJIGT) to monitor the implementation of territorial management instruments and evaluate territorial development. Its primary purpose is to provide a structured assessment of territorial dynamics through the systematic analysis of indicators, functioning as the documentary output of a continuous territorial monitoring process. However, although the REOT is legally conceived as the result of continuous monitoring, in practice it is still predominantly produced through periodic exercises of data collection, statistical analysis, territorial assessment, and report preparation. This discrepancy between its intended purpose and its operational implementation constitutes one of the principal motivations for the Dynamic REOT framework proposed in this paper, which seeks to transform the REOT from a static report into the on-demand output of a permanently updated territorial monitoring system.

The preparation of the Territorial Planning Status Report (REOT) is mandated by the Legal Framework for Territorial Management Instruments (RJIGT), which establishes monitoring and evaluation as essential components of the territorial governance system. Within this framework, the REOT constitutes the primary instrument for monitoring the

implementation of territorial management instruments, ensuring the systematic assessment of the effects of spatial planning policies and providing the technical evidence required to support the revision, amendment, or updating of territorial plans, particularly the Municipal Master Plan (Plano Diretor Municipal—PDM). Its periodic nature is intended to ensure that planning decisions are based on objective, up-to-date information supported by territorially consistent indicators.

This monitoring and evaluation framework is explicitly established by the RJIGT (Decree-Law No. 80/2015 of 14 May), which defines territorial monitoring and evaluation as core functions of the Portuguese spatial planning system. In addition, the National Programme for Spatial Planning Policy (Programa Nacional da Política de Ordenamento do Território—PNPOT) reinforces the importance of systematic territorial monitoring and evidence-based evaluation to support adaptive, coherent, and sustainable territorial governance (Figure 3).

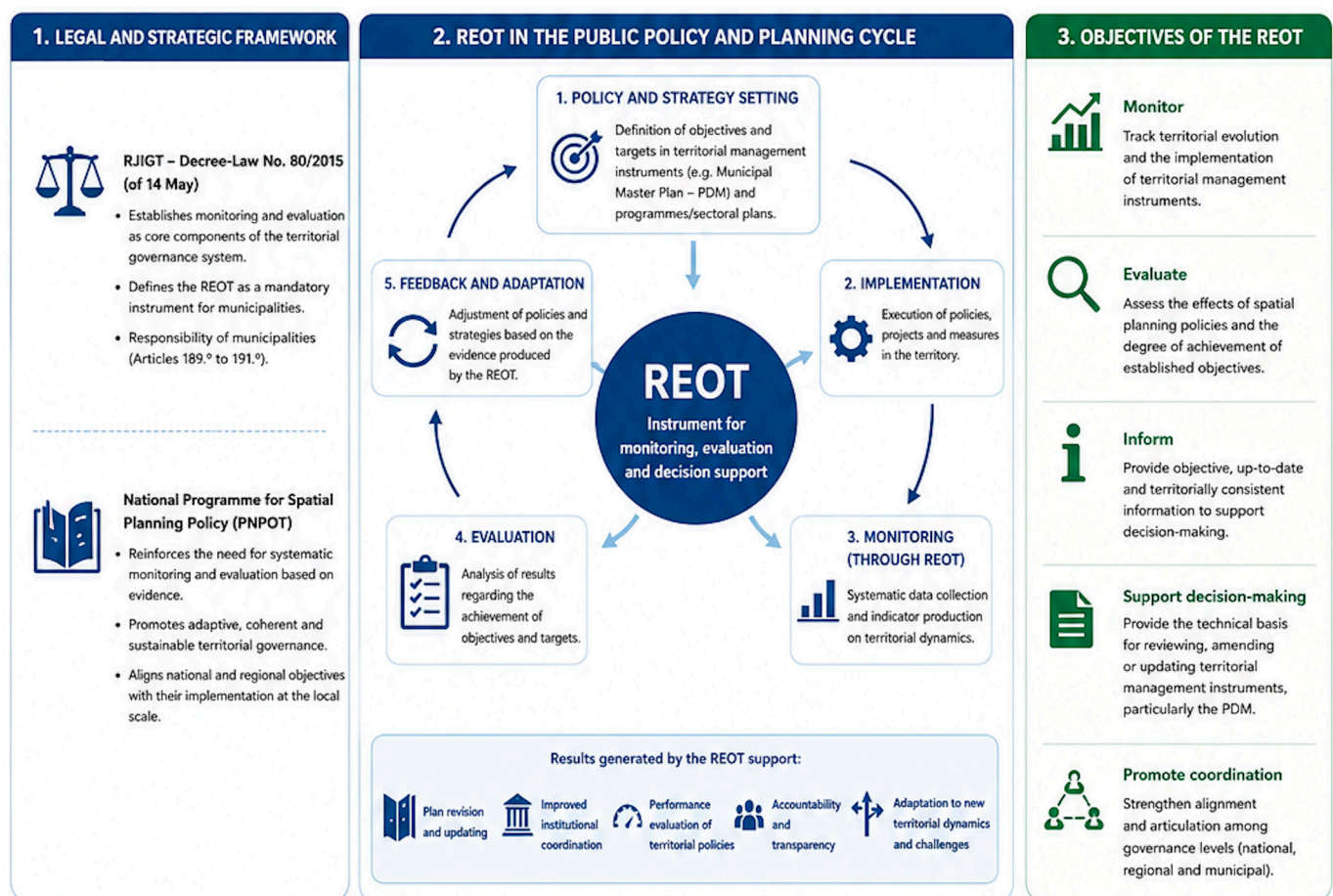


Figure 3. REOT role in the policy and planning cycle.

Beyond its monitoring function, the REOT plays a strategic role in fostering coordination across different levels of territorial governance. The report establishes a link between the objectives defined by national and regional spatial planning policies and their implementation at the municipal level, enabling the assessment of the effectiveness of territorial plans and programmes in achieving their intended outcomes. Consequently, it functions as a feedback mechanism within the spatial planning system, providing evidence that supports coordination among public authorities, the evaluation of territorial policy performance, and the adaptation of development strategies to emerging territorial dynamics.

The preparation of the REOT is the responsibility of municipalities and is typically carried out by in-house technical teams, although the engagement of external consultants

with expertise in spatial planning, Geographic Information Systems (GIS), and statistical analysis is also common. Its preparation entails significant technical and financial costs associated with the collection, harmonisation, and processing of data from multiple sources, the development of indicators, and the implementation of specialised spatial analyses. Although the legislation allows for formal stages of public participation, effective public engagement is generally limited and tends to be concentrated during the public consultation phase of the report. In practice, the REOT frequently assumes considerable political relevance, serving as an instrument for evaluating the performance of municipal administrations and ensuring public accountability. This political dimension may lead to differing interpretations of indicators and findings, reflecting the perspectives and interests of the various political stakeholders involved.

The local REOT allows for ongoing understanding of territorial dynamics, evaluating the responses of public policies and identifying unforeseen changes that may require adjustments to municipal development strategies. The preparation of the REOT, along with the information, indicators, and conclusions it produces, underpins the need to review territorial management instruments, particularly the Municipal Master Plan (Plano Diretor Municipal—PDM), enabling implemented public policies to be adapted based on concrete and up-to-date evidence.

In this context, the local REOT represents a fundamental stage in the public policy cycle: defining policies, implementing them, monitoring their effects, continuously evaluating, and, when necessary, correcting or improving policies and strategies. Therefore, its production should not be viewed as a sporadic exercise but as part of a continuous, dynamic (on-going) evaluation process, integrating monitoring and feedback into decision-making.

Despite its recognised importance within the Portuguese spatial planning system, the practical effectiveness of the REOT has been constrained by the inherent limitations of its traditional production model. In many municipalities, these reports continue to be prepared as static documents, produced periodically and heavily reliant on manual processes for data collection, integration, and processing. This approach hinders the continuous updating of indicators, limits comparability across different territorial scales, and reduces the capacity of the REOT to support timely decision-making processes. Consequently, a growing mismatch emerges between the actual evolution of the territory and the information made available to decision-makers, undermining the potential of the REOT as an instrument for continuous monitoring and evidence-based territorial governance (Figure 4). The pilot implementation presented later in this paper demonstrates that this limitation does not primarily result from technological constraints. Instead, it reflects the absence of continuously structured administrative information capable of supporting automated monitoring and reporting. This finding reinforces the need to reconsider not only how the REOT is produced, but also how territorial information is systematically managed throughout the planning cycle.

The REOT provides a chronologically organized view of territorial progress at the municipal scale, comparing local outcomes with national, regional, and local targets, and assessing whether policies and strategies need adjustment when results fall short of expectations or when higher-level directives change. This function reinforces its strategic position within the Portuguese territorial management system, consolidating the REOT as an essential tool for flexible, responsive, and adaptive planning practices.

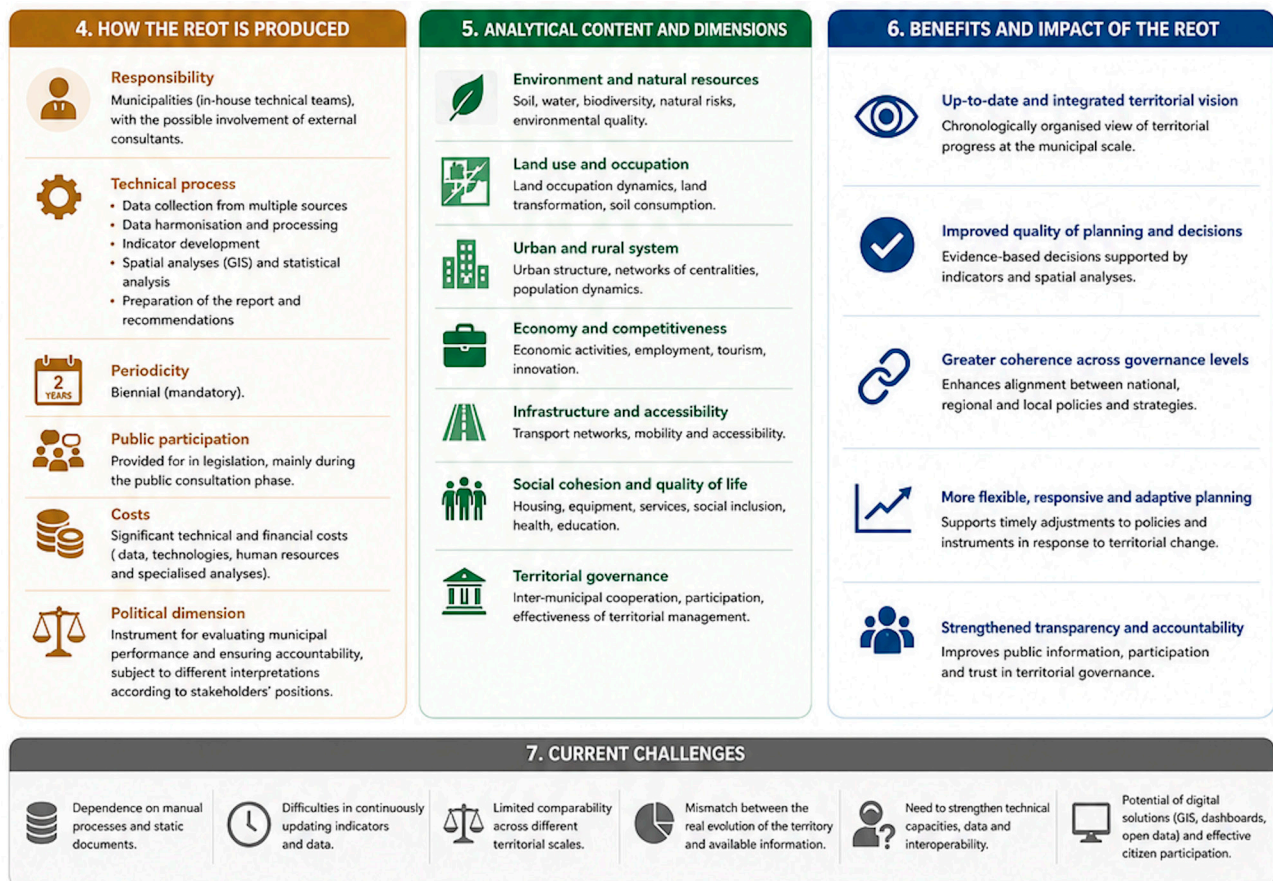


Figure 4. REOT production, analytical dimensions, benefits and current challenges.

3.2. Monitoring Territorial Dynamics and the Flexibility of the PDM

Contemporary urban and territorial planning emphasizes the flexibility and responsiveness of public policies to changes in territorial contexts during implementation. As Batista and Silva highlight, the territory possesses its own dynamics that are distinct from the planning process and plans. In analyzing plan implementation, analysts must avoid conflating the plan with the territory, recognizing that both are interdependent.

From this perspective, the PDM assumes even greater prominence, both as a plan and as an object of analysis and evaluation, particularly due to its dual reactive and proactive nature. It should be continuously updated in response to new policies, legal instruments, and observed territorial changes, maintaining alignment with strategic objectives. In Portugal, the lack of flexibility in first-generation PDMs proved detrimental, limiting adaptation to development opportunities and compromising coordination with other public policies. This issue persisted in second-generation PDMs and appears unresolved in third-generation plans currently under development.

Monitoring territorial dynamics is essential to ensure that the PDM fulfills its function as an adaptive policy instrument. This process involves continuous observation of the territory's state, transformations, and agent interactions, allowing the evaluation of public policy responses and timely adjustments to development strategies.

Beyond recording the current reality, monitoring enables the construction of historical databases in the form of Territorial Information Systems (Sistemas de Informação Territorial—SIT), ensuring continuity, consistency, and harmonization of territorial evidence. Continuous tracking allows for identifying gaps, evaluating PDM performance, and adjusting intervention measures, preventing deviations and inconsistencies in territorial development.

Continuous monitoring becomes even more critical in situations of informal urban growth (AUGI) or unplanned development areas, which can compromise the coherence of municipal strategies and require careful observation. In this context, the PDM functions as a strategic-operational instrument close to the population, fostering civic contributions to decision-making and increasing public acceptance of interventions.

3.3. Limitations of the Current REOT Production Model: From Static Reporting to Continuous Monitoring

The current production model of the State of Territorial Planning Report (REOT) is fundamentally organised around the preparation of a periodic statutory report. While this approach complies with the legal requirements established by the Portuguese Territorial Management System, it treats the REOT as the endpoint of a dedicated reporting exercise rather than as the natural output of a continuous territorial monitoring process. Each reporting cycle typically requires the collection, harmonisation, analysis, and interpretation of territorial information, followed by the preparation of a static document describing the state of territorial development at a specific point in time [13].

Although this production model has supported the implementation of the REOT since its introduction, it presents important operational limitations in an increasingly dynamic territorial context. Because territorial processes evolve continuously, much of the information used during report preparation may already be outdated by the time the report is completed. Consequently, the REOT frequently provides a retrospective assessment of territorial conditions rather than a continuously updated representation of the implementation and effects of territorial public policies. This temporal gap reduces its usefulness as a decision-support instrument and limits its contribution to adaptive territorial governance [7].

These limitations do not result from the absence of methodologies for preparing the REOT, but rather from the underlying production paradigm. Current methodologies are primarily designed to produce a report at predefined intervals, whereas the original purpose of the REOT is to monitor territorial evolution and support the continuous evaluation of territorial planning policies. In practice, the monitoring process is repeatedly reconstructed whenever a new report is required, instead of being maintained as a permanent activity integrated into the day-to-day management of territorial information.

The increasing availability of official statistical databases, geospatial information, administrative records, and open data services creates the conditions for adopting a different approach. Rather than periodically assembling information specifically for report production, territorial monitoring may be organised as a continuous process in which predefined indicators are systematically updated and made available through a permanent monitoring environment. Under this logic, the REOT ceases to be the mechanism through which territorial information is produced and instead becomes the documentary output of an ongoing monitoring process.

The practical feasibility of this approach is partially demonstrated through the *Cascais Experience* pilot presented in Section 4.5. Although limited to the urban planning management domain and not constituting a complete Dynamic REOT, the pilot confirms that municipal administrative information can be continuously integrated into a Planning Support System capable of automatically producing planning indicators and supporting on-demand reporting. The implementation also revealed that the principal barriers to dynamic territorial monitoring are organisational rather than technological, particularly regarding data governance, historical information consistency and indicator standardisation.

This conceptual shift constitutes the central premise of the Dynamic REOT proposed in this study. The Dynamic REOT is not intended to replace the existing statutory instrument, nor does it propose a new system of territorial indicators. Instead, it reconceptualises the

role of the REOT within the Portuguese territorial management system by transforming it from a periodically produced static report into an on-demand output generated from continuously updated territorial information. In this approach, the monitoring dashboard becomes the operational environment in which territorial indicators are permanently maintained and analysed, while the REOT represents a snapshot of the current state of the territory that can be generated whenever required (Figure 5).

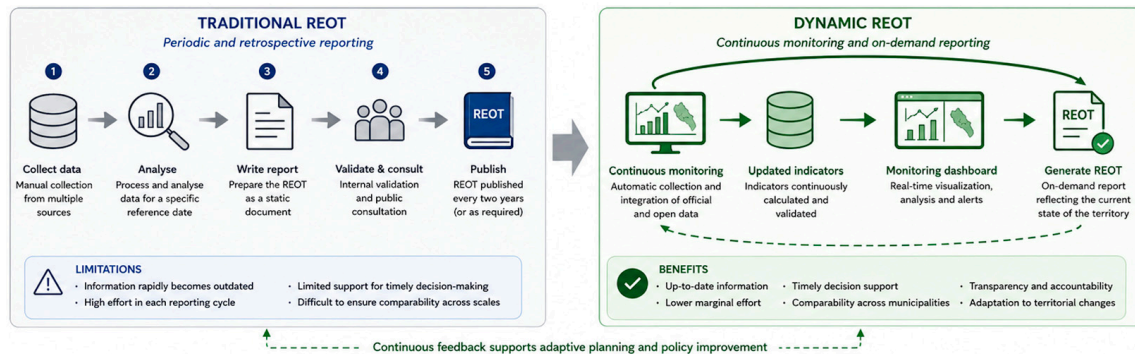


Figure 5. From Traditional (Static) REOT to Dynamic REOT—Paradigm Shift.

Accordingly, the innovation proposed in this paper is primarily methodological rather than technological. It consists of redefining the relationship between territorial monitoring and reporting, shifting the focus from the periodic production of a statutory document towards the continuous maintenance of a structured territorial monitoring environment. The conceptual framework presented in the following section is complemented by the *Cascais Experience* pilot implementation, which provides empirical proof of concept demonstrating that the proposed methodological approach is technically feasible using existing municipal administrative information and commercially available business intelligence tools (Figure 6).

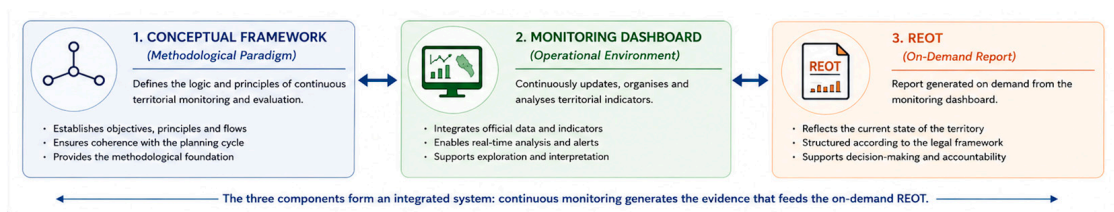


Figure 6. From traditional (Static) REOT to dynamic REOT—Components.

4. Developing a Planning Support System for the Dynamic REOT in the Portuguese Context

This section does not aim to provide an updated inventory of Planning Support Systems (PSS), as comprehensive reviews have already been presented by authors such as Stan Geertman and John Stillwell [7]. Instead, it focuses on the specific requirements of the Portuguese Territorial Management System (SGTP), whose institutional framework, legal context, and administrative organization require a tailored conceptual approach that cannot be fully addressed by existing generic PSS models.

Before presenting the proposed architecture, it is important to clarify the scope of this study. The objective of this paper is not to specify the technical implementation of a Planning Support System, nor to present an operational software platform capable of automatically producing REOTs. Rather, it introduces the conceptual foundations required to transform the REOT from a periodically produced statutory report into the documentary output of a continuous territorial monitoring process. To complement this

methodological proposal, the section concludes with the Cascais Experience, a pilot implementation that demonstrates the practical feasibility of several core components of the proposed framework.

Accordingly, the contribution of this paper is methodological rather than technological. The proposed architecture should therefore be understood as a functional and conceptual framework that identifies the logical components, workflows, and interactions required to support a Dynamic REOT, independently of the specific technologies adopted for implementation. It establishes the theoretical basis upon which future implementations may progressively evolve towards fully operational Dynamic REOT systems. The pilot implementation presented later in this section provides an initial empirical validation of this methodological framework while simultaneously identifying the organisational challenges that remain to be addressed before full implementation becomes feasible.

Consequently, the architecture presented in the following sections should be interpreted as a conceptual workflow rather than as a software specification. It describes how territorial information may be acquired, integrated, processed, analysed, and communicated within a continuous monitoring environment capable of supporting evidence-based territorial governance. Decisions regarding software platforms, database technologies, interoperability standards, cloud infrastructures, user interfaces, or specific Artificial Intelligence algorithms remain implementation choices that fall outside the scope of this article and should be addressed during subsequent empirical research.

The successful implementation of such a Planning Support System will ultimately depend on its ability to accommodate the institutional, economic, technological, demographic, and regulatory diversity that characterizes Portuguese municipalities. Rather than prescribing a single technological solution, the proposed framework emphasizes interoperability, methodological transparency, scalability, and adaptability as the fundamental principles required to support a harmonized national monitoring system while preserving the flexibility needed to respond to local territorial realities [14].

4.1. Conceptual Architecture of a Planning Support System Able to Produce the Dynamic REOT

The development of a Planning Support System (PSS) capable of supporting the dynamic production of the State of Territorial Planning Reports (REOT) must be grounded in a modular, integrated, and technologically robust architecture. Such an architecture should enable continuous territorial monitoring, automated calculation of relevant indicators, and the on-demand generation of updated evaluation reports (Figure 7).

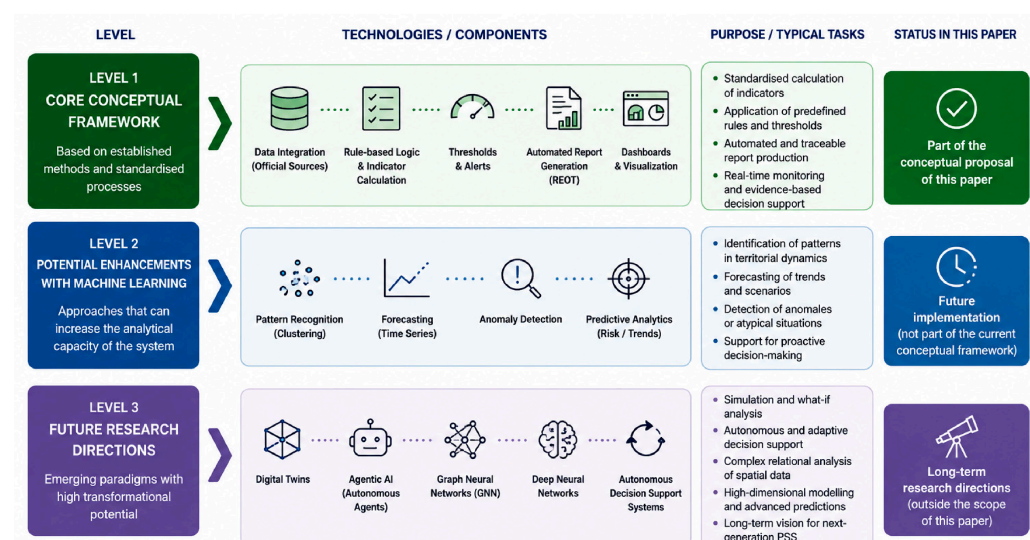


Figure 7. The role of technologies in the dynamic REOT framework.

It must be conceived from a broader and more integrated perspective, which has rarely been the case in practice, as most existing implementations have focused on specific-purpose tools or discrete sets of tools designed to address individual tasks within particular territorial contexts [14]. This broader systemic approach aligns with recent European trends in the application of Artificial Intelligence (AI) to urban and territorial governance, as illustrated by EU-supported smart city initiatives that integrate AI, open data, and interoperable infrastructures to improve urban performance and policy responsiveness, while preserving scalability and transferability across contexts.

Accordingly, the architecture of a PSS to be implemented in the Portuguese context should be structured into three interconnected layers:

- (a) Data Layer—Integrates official and territorialized data, statistical and administrative information (INE, PorData) complemented with public open data and real-time data from urban and mobility sensors. This layer ensures interoperability and compatibility between systems, building dynamic Territorial Information Systems (SIT) that record the temporal evolution of territorial phenomena.
- (b) This layer processes data according to methodologically defined territorial evaluation rules and logic, which should remain transparent, replicable, and scalable. These rules may include clearly defined threshold or benchmark values that facilitate comparability across municipalities and ensure compatibility with data aggregation at regional and national levels.

Once standardized processing is ensured, the system can support further context-specific analysis at the local scale through Artificial Intelligence (AI) techniques. These techniques enable pattern recognition, prediction of territorial dynamics, and identification of discrepancies between policy implementation and observed outcomes, thereby enhancing both monitoring and evaluative capacity. This way, AI-based contextual analysis operates on top of the standardized evaluation framework and does not alter the core harmonized indicators used for inter-municipal and national aggregation.

- (c) Presentation Layer—Consists of interactive and cross-sectoral dashboards that display the main territorial indicators, thematic maps, comparative analyses, and trends in near real time. Spatial and temporal visualization tools facilitate the understanding of policy impacts and support decision-makers and stakeholders. The automated generation of REOT should include interpretative text, charts, maps, and conclusions aligned with monitored evidence (for example, PowerBI).

4.2. Conceptual Workflow of the Dynamic REOT

The proposed Planning Support System is organized as a continuous monitoring workflow rather than as a sequence of isolated reporting activities. At the conceptual level, the system operates through six interconnected stages that progressively transform territorial data into monitoring evidence and, ultimately, into an automatically generated REOT.

- (a) Data acquisition, through the periodic integration of official spatial, statistical and administrative data sources;
- (b) Data preparation, including validation, cleaning, harmonization, normalization and georeferencing;
- (c) Indicator production, by applying predefined formulas and methodological rules to generate standardized territorial indicators;
- (d) Monitoring and evaluation, where indicators are compared with reference values, targets or thresholds to identify trends, deviations and situations requiring attention;
- (e) Communication, through dashboards, maps, charts and interactive visualizations that provide continuous access to updated territorial information;

- (f) REOT generation, where the monitoring outputs are automatically organized according to the statutory REOT structure, producing an updated report on demand.

This workflow represents the logical organization of the monitoring process (Figure 8). It does not prescribe specific software platforms or computational technologies, which remain implementation choices to be addressed during future empirical development.

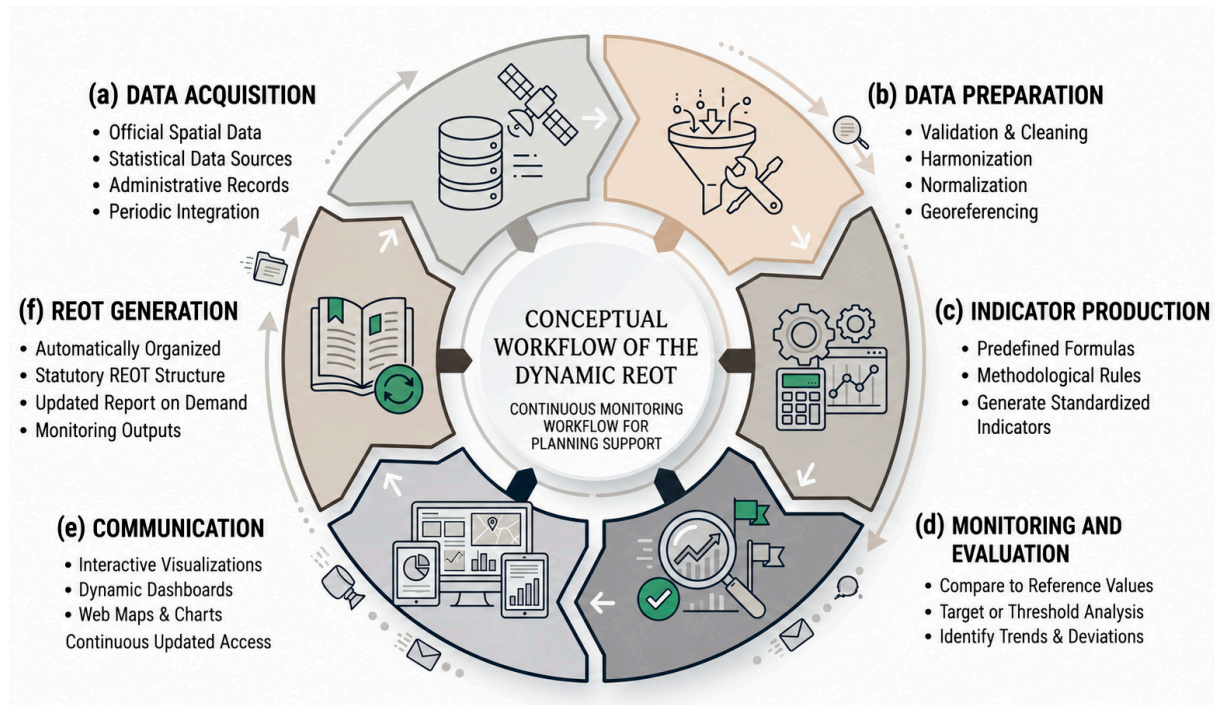


Figure 8. Conceptual workflow for the dynamic REOT.

4.3. Definition and Operationalization of Territorial Indicators in the Portuguese Context

Territorial indicators are the central element of monitoring. The selection of indicators is based on criteria of political relevance, data availability, and their capacity to continuously reflect the state and dynamics of the territory in relation to public policy objectives.

These indicators are designed to capture, for example:

- Demographic and socio-economic evolution (density, income, employment);
- Changes in land use and urban occupation;
- Mobility and accessibility (including public transport data, traffic, and urban flows);
- Environmental indicators (air quality, resource consumption, green area coverage);
- Infrastructure and public services (access and capacity);
- Deviations and inconsistencies between the plan (PDM or other instruments) and observed territorial transformations.

These indicators must be automatically updated based on inputs from data sources, allowing longitudinal and comparative analyses across periods, territories, and scales. The combination of AI with open data and urban sensors, as in smart city projects, demonstrates that such systems can reflect the territory's operation in real time, thereby enhancing the impact assessment and performance evaluation of policies [16].

However, in the Portuguese context, the implementation of this type of integrated monitoring system faces significant challenges. The main obstacle is not the lack of formal recognition of the importance of evaluation and monitoring. On the contrary, evaluation is legally required within the framework of spatial planning instruments, including Municipal Master Plans (PDM). The difficulty lies rather in the limited allocation of financial, technical, and human resources necessary to operationalize continuous monitoring systems. In many

cases, evaluation remains a formal obligation, without a corresponding investment in data infrastructures, analytical capacity, or dedicated teams capable of ensuring systematic follow-up.

There are nevertheless relevant examples of local implementation. Municipalities such as Amadora, Cascais and Porto have developed monitoring platforms and smart city initiatives integrating open data, sensors, and performance indicators. These experiences demonstrate technical feasibility and institutional innovation. However, they tend to be tailor-made solutions, designed according to local priorities and supported by locally produced data. As a result, they lack harmonization and interoperability at the national level, limiting comparability across territories and constraining the construction of a coherent national monitoring framework.

Given the diversity of territorial realities, it is neither realistic nor desirable to construct an exhaustive and uniform set of indicators capable of responding to every municipality's specific monitoring needs. Instead, a multi-level governance approach appears more viable. At the regional scale, the Comissões de Coordenação e Desenvolvimento Regional (CCDR) are strategically positioned to define a limited set of core territorial indicators. These key indicators could function as the backbone of a harmonized monitoring system, ensuring minimum comparability, methodological coherence, and alignment with national policy objectives.

Such an approach follows a principle of “doing more with less”: rather than producing an extensive and unmanageable list of indicators, the system should prioritize a concise, robust, and policy-relevant set of metrics. Combined with local complementary indicators tailored to municipal specificities, this structure would allow both flexibility and coherence, strengthening the culture of evaluation and enabling more evidence-based territorial governance in Portugal.

The pilot implementation developed within the Municipality of Cascais confirms the practical relevance of this approach. Rather than attempting to construct an exhaustive indicator framework, the dashboard was progressively developed according to the availability, consistency and reliability of municipal administrative data. This iterative process demonstrated that indicator definition should not be driven exclusively by theoretical requirements but also by the quality and maturity of the underlying information systems.

4.4. Data Integration and Automation Workflow for Automated REOT Production

The integration of AI rules and intelligent automation into the system must be established as a guiding principle of the territorial governance model. Automation should not be limited to structured tasks, such as metric calculation, but must incorporate agentic capabilities that enable responses to complex and dynamic situations. In line with developments in smart city strategies, as seen in Singapore and Barcelona, artificial intelligence should be used to manage complex urban flows, optimize operations, and support real-time decision-making.

Within this framework, the system must ensure the full automation of the monitoring process that underpins REOT production. Its logic should coherently combine transparent rules defined by public policies and explicit technical criteria, thereby ensuring traceability and institutional legitimacy; predictive and descriptive AI models capable of identifying emerging patterns, anticipating trends, and interpreting complex relationships among territorial variables; and intelligent automation mechanisms that structure and orchestrate workflows for the continuous execution of repetitive or complex tasks, freeing technical resources for critical analysis and strategic formulation.

REOT production should therefore no longer depend on manual processes but instead result from a permanent and automated system. The report should not be understood as

an isolated task, but as an output automatically generated from a continuous cycle of data collection, analysis, and interpretation. To achieve this, the process must follow a consistent and replicable sequence: systematic preparation of data and indicators for the reference period; automatic analysis of trends, deviations, and warning signals; interpretative synthesis combining quantitative evidence with qualitative assessment; structured construction of the final report, integrating analytical text, tables, maps, and recommendations; and export in interoperable formats, such as PDF and web interfaces.

All Planning Support Systems (PSS) must structure their system architecture as the backbone of the entire automated workflow. This architecture should be organized into six interconnected stages that ensure coherent data integration, processing, and interpretation. First, data ingestion must enable the automatic extraction of official and open data sources, including sensors and urban platforms, followed by normalization and georeferencing. Second, preprocessing must guarantee data validation, cleaning, and harmonization in order to ensure quality, consistency, and reliability. Third, indicator calculation must apply predefined rules and analytical models to derive territorial indicators from raw data. Fourth, AI analysis must employ machine learning techniques and rule-based logic to detect trends, predict dynamics, and anticipate potential impacts. Fifth, dashboards and Territorial Information Systems (SIT) must be continuously updated, ensuring real-time visualization and accessibility of results. Finally, automated REOT production must synthesize structured outputs, conclusions, and policy recommendations derived from the previous stages.

Through this structured architecture, the REOT must be transformed from a traditionally static and retrospective document into a dynamic, adaptive, and proactive instrument. It should reflect the real-time evolution of the territory and actively support decision-making processes informed by both current data and predictive evidence. In this way, the REOT becomes an integral and continuous component of the public policy cycle: policies are defined, implemented, monitored in real time, evaluated on an ongoing basis, and systematically adjusted in response to evidence generated by the system itself.

4.5. Pilot Demonstration and Empirical Validation: The Cascais Experience

To explore the practical feasibility of the conceptual framework proposed in this paper, a pilot implementation was developed within the Municipality of Cascais under the initiative designated Cascais Experience. It is important to clarify from the outset that this initiative does not constitute a Dynamic REOT, nor was it designed to automatically generate the statutory State of Territorial Planning Report (REOT). Instead, it represents a dynamic urban planning dashboard that demonstrates the technical feasibility of continuously integrating administrative data, producing planning indicators on demand, and supporting municipal decision-making through an interactive Planning Support System (PSS).

The pilot focused exclusively on the urban planning management domain, using data generated through the municipality's Urban Management Platform. This platform functions as the municipality's primary administrative information system for planning procedures, continuously updated by municipal technicians during the normal processing of planning applications. Rather than creating a new database, the pilot aggregated, organized and interpreted existing administrative records through Microsoft Power BI, allowing the construction of a dynamic monitoring environment based entirely on operational municipal data.

Unlike traditional REOT preparation, which normally requires a dedicated process of data collection and statistical treatment, the Cascais Experience sought to demonstrate that the continuous organization of administrative information enables the automatic production of indicators whenever required. Consequently, the dashboard operates as an

on-demand monitoring system, where indicators are updated directly from the administrative database, significantly reducing the need for manual statistical compilation.

The implementation relied predominantly on internally generated municipal data. The main information sources included planning applications, procedural requests, administrative records, notifications, procedural milestones, operation typologies and processing dates extracted from the Urban Management Platform. Since these data are continuously generated during the normal operation of municipal services, indicator production is not constrained by predefined reporting cycles but instead reflects the current state of planning activity at any given moment (Figure 9).



Figure 9. Conceptual workflow of the pilot implementation.

One of the principal findings of the pilot concerns the definition of indicators. Rather than starting from a predefined theoretical framework, indicator selection was largely determined by data availability, consistency and reliability. Although urban planning procedures contain a considerable amount of potentially useful statistical information, much of these data require substantial preprocessing before becoming suitable for monitoring purposes. Data cleaning, validation, normalization and categorization proved to be essential stages of the implementation process, highlighting that the production of meaningful indicators depends as much on data governance as on computational capabilities.

The dashboard was structured into four complementary levels of information, reflecting different management needs within the municipal organizational hierarchy (Figure 10).

Dashboard Level	Primary Users	Main Purpose	Type of Indicators
 Level 1 – Operational Overview	Department Heads	Daily service monitoring	Operational management
 Level 2 – Performance	Managers and Decision-makers	Evaluate administrative efficiency	Time-based KPIs
 Level 3 – Productivity	Technical Coordinators	Measure productivity by procedure type	Productivity indicators
 Level 4 – Urban Development	Strategic Planning	Understand territorial dynamics	Urban planning indicators

Figure 10. Levels of the pilot implementation.

The first level provides an operational overview of the service through general management indicators, including the total number of planning applications, processed requests, administrative records and notifications issued (Figure 11).

Dashboard Level	Indicator	Data Source	Update Frequency	Management Objective
Operational Overview	Number of Planning Applications	Urban Management Platform	Continuous	Monitor planning activity and workload
	Processed Requests	Urban Management Platform	Continuous	Assess administrative workflow and process dynamics
	Total Administrative Records	Urban Management Platform	Continuous	Evaluate overall operational intensity
	Notifications Issued	Urban Management Platform	Continuous	Monitor communication with applicants
Performance	Average Licensing Approval Time (days – working days)	Administrative records	Continuous	Measure administrative efficiency
	Average Licensing Refusal Time (days – working days)	Administrative records	Continuous	Monitor decision-making performance
	Average Time Since Last Interaction with Applicant (days – working days)	Administrative records	Continuous	Evaluate perceived responsiveness from the applicant perspective
Productivity	Planning Procedures by Type	Urban Management Platform	Continuous	Compare productivity across different procedure categories
	Completed Procedures	Urban Management Platform	Continuous	Measure operational output
Urban Development	Types of Urban Development Operations	Urban Management Platform	Continuous	Identify investment patterns and urban development trends

Figure 11. Indicators of the pilot implementation.

These indicators provide an immediate assessment of the operational activity of the planning department, allowing managers to monitor workload, service intensity and overall administrative performance. Their combined interpretation also supports a broader understanding of planning dynamics, revealing variations in demand for urban development and changes in municipal processing capacity over time.

The second level focuses on performance indicators, particularly those related to processing times. Average licensing approval time and average licensing refusal time constitute important measures of administrative efficiency. However, the pilot also demonstrated that one particularly relevant indicator is the average elapsed time since the last interaction with the applicant. From the applicant's perspective, this measure better reflects the perceived responsiveness of the administration than total processing time alone, reducing uncertainty throughout complex licensing procedures and providing a more meaningful indicator of service performance.

The third level addresses productivity by disaggregating planning activity according to different procedural categories. Since planning procedures differ considerably in terms of complexity, duration and legal requirements, aggregated productivity indicators may produce misleading interpretations. The dashboard therefore allows separate monitoring of different operation types, enabling a more realistic assessment of municipal performance.

Finally, the fourth level introduces indicators associated with urban development dynamics, particularly the distribution of different types of planning operations registered within the municipality. These indicators begin to approach the broader monitoring objectives normally associated with the REOT, allowing the identification of development trends, investment patterns and changes in the dominant forms of urban intervention over time.

Although the Cascais Experience was not designed as a Dynamic REOT, it validates several fundamental components of the conceptual architecture proposed in this paper. The pilot demonstrates that continuously updated administrative databases can successfully support automated indicator production, interactive dashboards and on-demand reporting using commercially available business intelligence tools such as Microsoft Power BI. More importantly, it confirms that the principal challenges associated with implementing dynamic monitoring systems are not primarily technological (Figure 12).

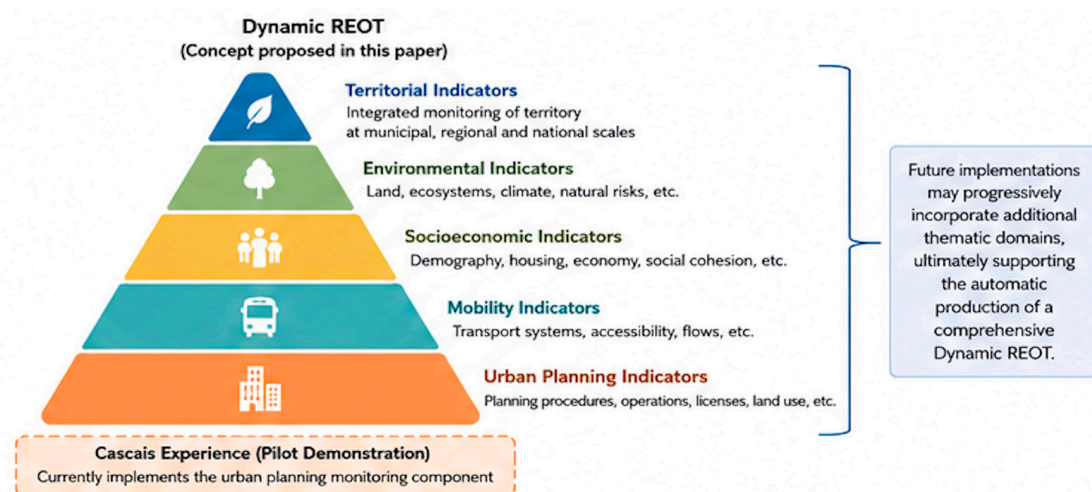


Figure 12. Relationship between the Pilot and the proposed concept for a Dynamic REOT.

The experience revealed that the greatest difficulty lies in the historical organization of administrative information. Existing municipal information systems were originally designed to support procedural management rather than continuous statistical analysis. Consequently, information is frequently stored without standardized structures that facilitate future aggregation, longitudinal analysis or automated indicator production. While software platforms and computational resources are now sufficiently mature to support dynamic monitoring, the absence of systematic procedures for structuring, validating and maintaining administrative information remains the principal barrier to implementing automated territorial monitoring systems.

The Cascais Experience therefore provides an important empirical contribution to the conceptual framework proposed in this paper. Although it does not constitute a Dynamic REOT, it demonstrates that the transition from static reporting towards continuous territorial monitoring is technically feasible. At the same time, it highlights that future implementation efforts should prioritize data governance, information standardization and institutional procedures, since these constitute the fundamental prerequisites for any future automated REOT production system.

Beyond its technical contribution, the Cascais Experience also demonstrates an important conceptual shift. The value of a dynamic monitoring system does not lie solely in automating report production, but in establishing a permanent culture of information management capable of continuously supporting territorial governance. In this sense, the pilot should be understood not as a simplified Dynamic REOT, but as an operational proof of concept demonstrating that continuous administrative monitoring constitutes a realistic and scalable pathway towards future Dynamic REOT implementation in Portuguese municipalities.

5. Challenges in the Implementation of a Planning Support System in the Portuguese Context

5.1. Challenge 1: Platform

The Planning Support System should be implemented as a support tool within an interactive web platform, based on dashboards with user-friendly interaction and an appealing interface (e.g., PowerBI), enabling continuous access to territorial information and the dynamic generation of REOT.

This tool represents the first major challenge, not only in terms of technical and operational requirements but, above all, regarding its effective usability across municipalities with very different realities. In Portugal, municipal technological capacities are closely linked to their respective budgets, resulting in significant heterogeneity nationwide. While Lisbon has a municipal budget of approximately €1.345 billion (2026), smaller municipalities, such as Constância, operate with much more limited budgets, around €13.1 million for the same period.

This budget disparity translates into varying levels of technological infrastructure, specialized human resources, and the capacity to invest in proprietary software or advanced data analysis solutions. In this context, selecting the tool should not rely solely on meeting sophisticated technical requirements but primarily on its scalability, flexibility, and adaptability to diverse institutional contexts.

It is therefore essential to prioritize solutions that ensure interoperability with other statistical software and territorial information systems, enabling seamless data integration and avoiding excessive technological dependencies. The adoption of open-source solutions emerges, in this context, as a strategic option—not only for reducing licensing costs but also for greater transparency, customization possibilities, and long-term sustainability—promoting a more equitable and feasible implementation of the Planning Support System across the entire national territory.

The Cascais Experience confirmed the practical viability of this approach through the implementation of a dashboard developed using Microsoft Power BI. Rather than functioning as an independent information system, the dashboard operates as a business intelligence layer that aggregates and structures administrative information extracted from the municipality's Urban Management Platform. This architecture demonstrates that the development of dynamic monitoring environments does not necessarily require replacing existing municipal information systems but rather enhancing their analytical capabilities through interoperable visualization tools.

The dashboards should be designed to visualize, analyze, and interpret territorial data intuitively, allowing different users—decision-makers, planning professionals, and interested public—to interact with the indicators and obtain strategic insights.

These dashboards must incorporate summarization capabilities, since information overload can hinder evaluation, with the main functionalities including:

- (a) Interactive visualization of spatial and temporal indicators through maps, charts, and dynamic tables;

- (b) Customizable filters allowing segmentation by municipality, region, time period, and category of public policy;
- (c) Automatic alerts regarding deviations or trends that indicate the need for policy or territorial management instrument review;
- (d) Report export, integrating the automatic production of REOT.

A platform with these characteristics would embed the logic of continuous monitoring (on-going) rather than episodic evaluations, enabling near real-time updates and aligning with trends observed in smart cities, where AI integrates open data, urban sensors, and information systems to optimize urban flows and territorial management (Figure 13).

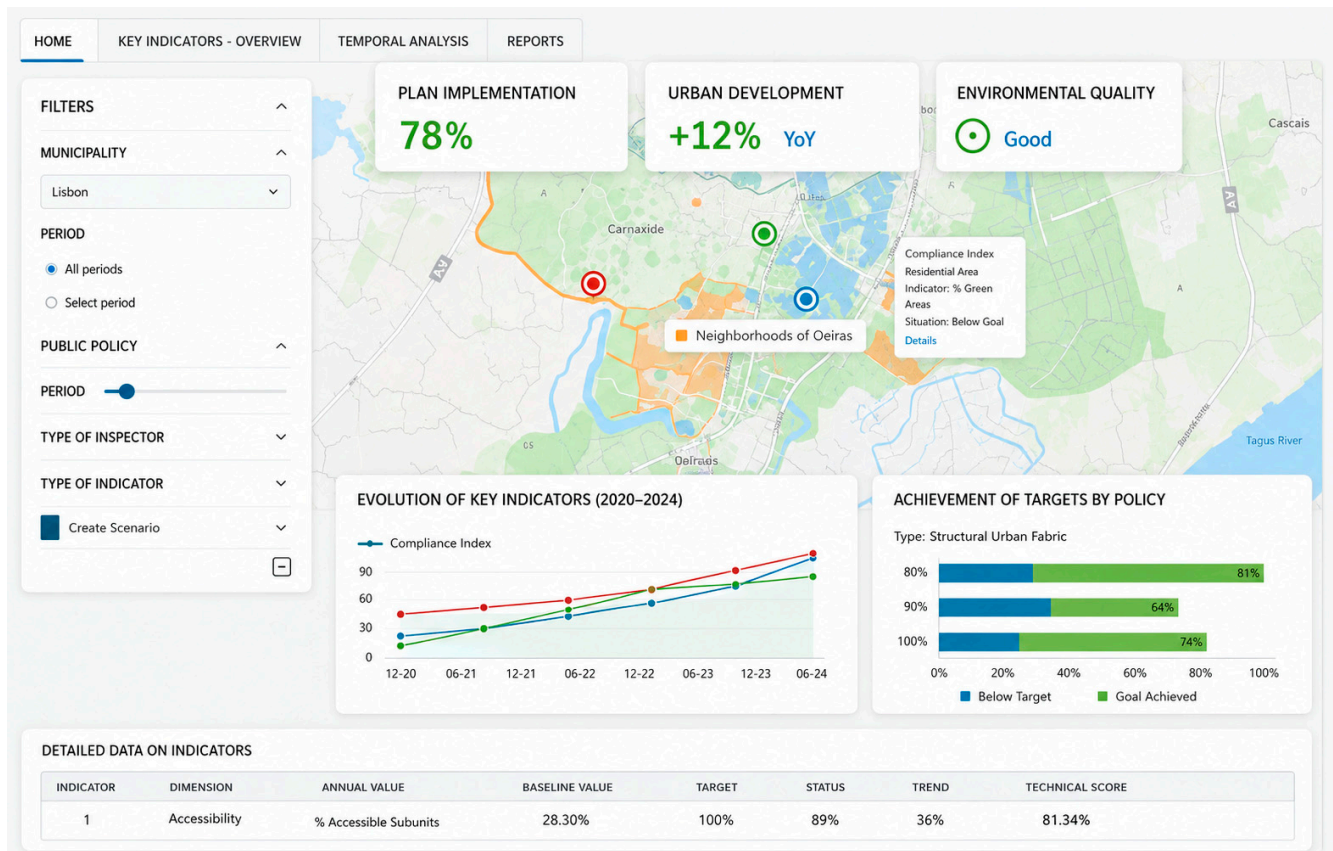


Figure 13. Example of a possible dashboard interface for the Dynamic REOT, showing visualization of metrics, indicators, and interactive controls for real-time monitoring.

5.2. Challenge 2: Data Sources Used

Since a Planning Support System operates with confidential information, whose access and use must be subject to security restrictions, the same security concerns must be applied to the platform's data input. This entails limiting the data sources to official and public sources, including:

- (a) Spatial data such as cadastral maps, land use, transport networks, and urban infrastructures;
- (b) Statistical data including demographics, employment, socioeconomic, and environmental indicators;
- (c) Real-time sensors and data such as urban mobility, air quality, energy consumption, and urban flows;
- (d) Public policy data including information on municipal, regional, and national plans, as well as program and project execution;
- (e) Historical data capturing the evolution of indicators over time, allowing for comparative and longitudinal analyses.

- (f) Relying solely on secure sources ensures that the data are appropriate for analysis, enhances the usefulness of evaluations, and guarantees the reliability of the REOT. All data should be georeferenced and integrated into Territorial Information Systems (SIT), ensuring interoperability across scales and consistency in indicator production.

The pilot implementation also demonstrated that the principal difficulty is not the absence of data but rather their organisation. Although municipal information systems generate a considerable amount of administrative information during the processing of planning applications, these data are not usually structured for statistical analysis or indicator production. Considerable effort was therefore required to clean, classify, standardise and validate the available information before it could be integrated into the dashboard. This experience highlights that data governance constitutes one of the main prerequisites for future dynamic REOT implementation.

5.3. Challenge 3: Methodological Principles for Monitoring and Evaluation

Monitoring and evaluation in territorial planning operate across three complementary levels: the plan itself, which involves the analysis of objectives and targets; plan compliance, which assesses the extent to which implementation aligns with the intended policies; and the real system, which monitors the territorial dynamics resulting from policy execution. At this latter level, effective monitoring requires a clear definition of objectives, timeframes, indicators, and responsibilities, ensuring that the information produced is actionable and supports future decision-making.

To ensure the effective implementation of a Planning Support System, seven methodological principles must be observed [3]: Usefulness; Incrementality; Regularity; Articulation; Harmonization; Selectivity and efficiency; impartiality (Figure 14).

1. First, usefulness requires that information be oriented toward improving public policies, validating decisions, and understanding territorial responses to interventions;
2. Incrementality refers to the gradual development of the system, allowing it to evolve according to available resources and data, with indicators adjusted as new information becomes accessible;
3. Regularity emphasizes continuous monitoring through periodic cycles of data collection and analysis, using consistent methods over time to enable chronological analyses and the identification of trends;
4. Articulation highlights the need for integration across sectors, levels of government, and stakeholders, promoting horizontal and vertical coordination to support more effective decision-making;
5. Harmonization involves the adoption of compatible indicators and methodologies across municipalities and spatial scales, facilitating reliable comparisons and data aggregation;
6. Selectivity and efficiency stress the importance of using a limited set of representative indicators to avoid information overload while ensuring operational feasibility;
7. Finally, impartiality requires neutrality and transparency in the evaluation process, involving both internal and external actors to reduce bias and ensure credibility.

These methodological principles were progressively applied during the Cascais Experience. In particular, the principles of Incrementality and Selectivity proved fundamental. Rather than attempting to implement an exhaustive monitoring framework from the outset, indicators were gradually incorporated according to the availability, consistency and reliability of the underlying administrative information. This iterative development process significantly reduced implementation complexity while improving the robustness of the resulting indicators.

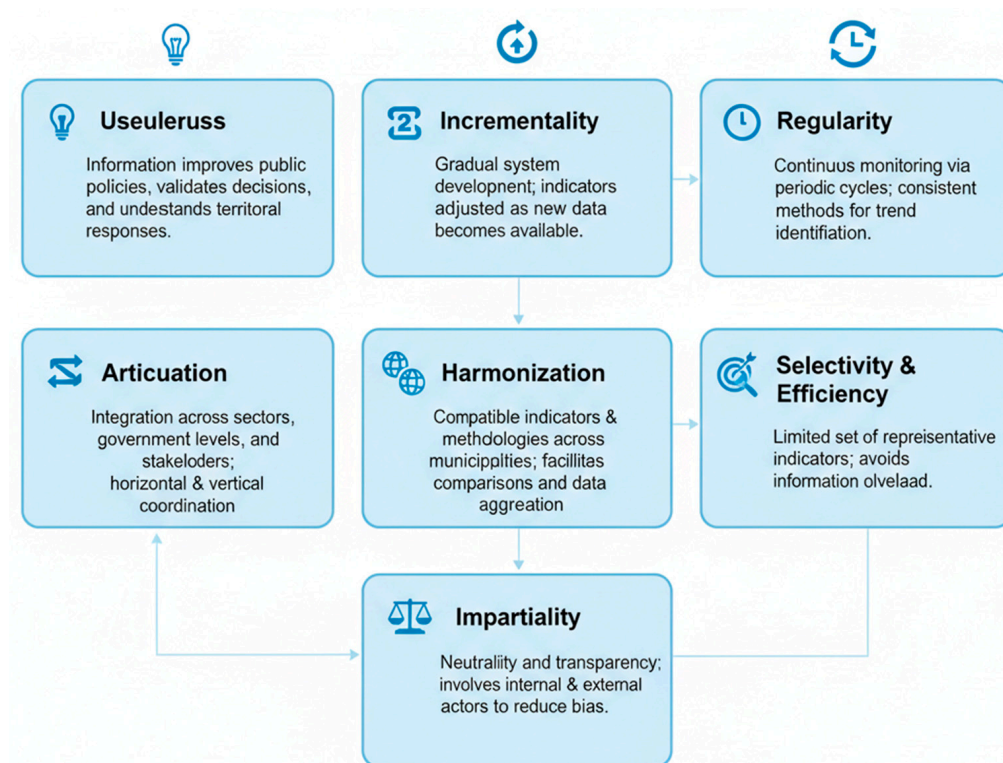


Figure 14. Methodological principles of the dynamic REOT.

5.4. Challenge 4: Application in the Portuguese Context

In Portugal, Municipal Master Plans (PDMs) constitute the primary instrument of local territorial planning, responsible for defining public policies, organizing land use, and guiding the sustainable development of municipalities. First-generation PDMs, developed mainly during the 1990s, were based on outdated growth projections and limited information which was not designed to be monitored and was not a priority. Nevertheless, subsequent monitoring revealed significant discrepancies between planning provisions and territorial reality, including the occupation of unplanned areas and difficulties in adapting to emerging territorial dynamics [10].

Second-generation PDMs introduced a more strategic and operational approach, providing greater flexibility and allowing for plan revisions. This evolution enables territorial management instruments to be adjusted on the basis of continuous monitoring of territorial dynamics. Within this framework, the REOT has become a mandatory instrument, produced by municipalities on a biennial basis, and currently serves as the main mechanism for the continuous evaluation of Municipal Master Plan implementation. The preparation of a dynamic REOT allows for the assessment of the effectiveness of implemented public policies, thereby providing a robust foundation for decisions regarding the need to revise the PDM.

The Cascais Experience further demonstrated that the technological component represents only one dimension of implementation. Existing business intelligence software already provides the functionalities required for dashboard development, automated calculations and interactive reporting. However, successful implementation depends primarily on institutional organisation, the standardisation of administrative procedures and the systematic production of high-quality information throughout the planning process. These organisational aspects emerged as considerably more challenging than the technological implementation itself.

To adequately fulfill this role, the REOT must integrate information on territorial history, recent dynamics, and emerging trends. This integration ensures continuous and permanent territorial monitoring, rather than sporadic or occasional evaluations, thereby strengthening its contribution to informed and adaptive planning processes [10,17].

In this regard, the coordinated use of open data, urban sensors, and artificial intelligence technologies enables the development of a more detailed, continuous, and proactive model of territorial monitoring. Municipal GIS platforms support advanced spatial analyses, systematic cross-referencing of information, and the harmonization of data from multiple institutional and sectoral sources.

In this context, artificial intelligence and machine learning models enhance the detection of complex patterns and the anticipation of urban trends, moving beyond purely descriptive and reactive approaches [37]. These capabilities are aligned with European smart city initiatives, particularly the objectives of Horizon Europe, which emphasize the strategic use of data to support adaptive public policies. This technological framework strengthens the management of urban flows, mobility, land use, and environmental sustainability by enabling faster and more informed responses to emerging changes and structural transformations [30].

5.5. Challenge 5: Defining Indicators for the Dynamic REOT

The biennial REOT enables the identification of gaps in the implementation of public policies and the validation of the correspondence between expected outcomes and actual results. It also supports the proposal of adjustments to Territorial Management Instruments, including revisions of the Municipal Master Plan (PDM) when necessary. In addition, the REOT feeds dashboards with both historical and recent data, facilitating longitudinal analyses and the identification of trends over time. Taken together, these functionalities contribute to stronger evidence-based policy support by integrating information from different sectors and levels of governance. To fulfill these functions, a robust and methodologically grounded system of indicators is required.

When properly designed and implemented, indicators translate into tangible benefits and positive impacts, particularly by providing continuous feedback to public policies, enabling timely adjustment of plans, programs, and territorial management instruments. They also contribute to greater flexibility in the Municipal Master Plan (PDM), ensuring that planning instruments adapt to new realities and emerging territorial dynamics. They also enhance transparency and public participation through the integration of open data and the provision of accessible information. Their use further promotes evidence-based decision-making, guiding municipal and regional decisions based on objective indicators and the analysis of territorial trends. Finally, they facilitate national-level harmonization by aligning data and indicators across municipalities, enabling aggregation, comparability, and systematic monitoring.

The definition of indicators for the development of a Planning Support System (PSS) aimed at producing a dynamic REOT in Portugal should adhere to the seven methodological principles established in Challenge 3: Usefulness, Incrementality, Regularity, Articulation, Harmonization, Selectivity and Efficiency, and Impartiality (Figure 15). This process is structured in two main phases: an initial start-up phase, designed to ensure minimum operational capacity and national consistency, and a later phase, which assumes a consolidated, cross-cutting planning culture that allows the evolution, deepening, and expansion of indicators' scope and detail.

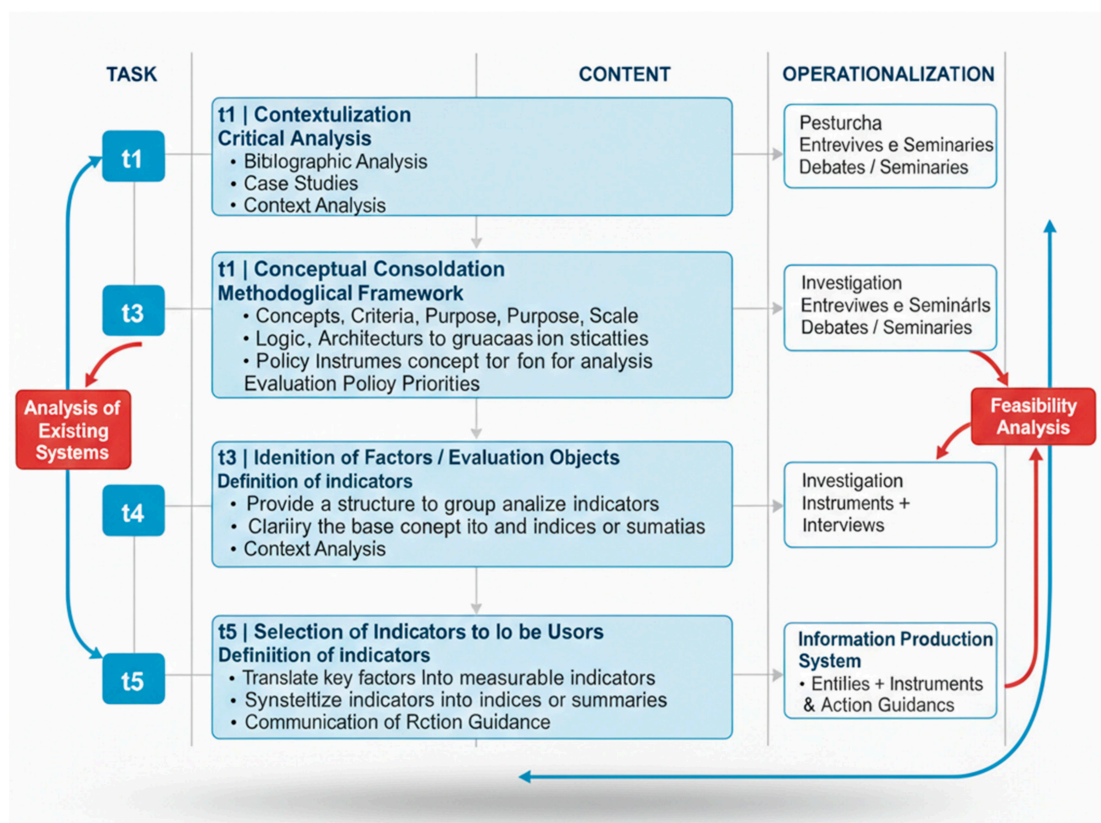


Figure 15. Dynamic REOT indicator development framework.

In the first phase, the primary objective is to apply the principle of “doing more with less,” addressing the asymmetry observed between municipalities in terms of capacity to produce indicators and territorial coverage of information. Official sources, such as the National Institute of Statistics (INE), are prioritized to ensure comparability and uniformity. Based on this framework, a set of structuring tasks guides the definition of an initial battery of indicators, common to all municipalities, which can later be locally refined without compromising national aggregation and ongoing monitoring (Figure 15).

The Cascais Experience demonstrated that indicator selection should not be driven exclusively by theoretical relevance but also by data availability, consistency and operational feasibility. The pilot therefore adopted a pragmatic approach in which indicators were progressively defined according to the quality of the available administrative information. This resulted in four complementary groups of indicators: (i) general operational indicators describing municipal activity (e.g., number of planning applications, requests processed, records and notifications); (ii) performance indicators measuring processing times and administrative responsiveness; (iii) productivity indicators analysing different categories of urban planning procedures; and (iv) contextual indicators supporting the interpretation of planning activity. This experience confirms that the development of Dynamic REOT indicators should follow an incremental methodology, allowing municipalities to progressively expand their monitoring capabilities as information systems mature.

Stage 1, corresponding to the development of the methodology and the structuring of the monitoring system, unfolds through five interdependent tasks:

Contextualization (t1): Involves bibliographic research on the current state of territorial planning evaluation, selection of reference case studies, and definition of the methodological focus.

Conceptual Consolidation (t2): Establishes the methodological framework, defining concepts, criteria, monitoring priorities, and system logic. Expert input through seminars

and interviews ensures early identification of gaps or redundancies and promotes consensus among internal and external stakeholders.

Analytical Structure (t3): Organizes the critical factors (CF) for monitoring and outlines the framework on which indicators will be developed.

Identification of Available Indicators (t4): Translates the critical factors into measurable indicators, assessing their versatility, scope, and utility. While some indicators may provide limited insight individually, their combined analysis can generate richer understanding, making careful evaluation essential.

Selection of Indicators to Use (t5): Defines the system for producing underlying data, including instruments and information channels, and evaluates indicators' applicability to ensure national harmonization. This step refines the initial battery, identifying the minimum necessary set to enable consistent monitoring of territorial planning across Portugal.

Each indicator must be documented in a standardized sheet covering nine sections: (1) designation, (2) description, (3) calculation formula, (4) scope, (5) production, (6) internal handling, (7) public dissemination, (8) potential graphical representations, and (9) identification of weaknesses. Thus, indicators are categorized into three groups:

- (a) Key Indicators (IC): Summarize and allow direct monitoring of the territorial object.
- (b) Satellite Indicators (IS): Extend ICs, providing more detail without significantly increasing production effort.
- (c) Specific Indicators: Reflect local or contextual particularities, which may not be aggregable at the national level.

The implementation of these tasks is not strictly linear. Rather, it is cyclical and iterative, allowing feedback loops whereby decisions or adjustments in one phase may necessitate returning to a previous phase. This approach ensures adaptability, the incorporation of new information, and robustness of the system.

Integration with national data sources and open-data infrastructures ensures that the monitoring system is flexible, scalable, and responsive to emerging needs. Municipalities can progressively enhance their indicator sets and analytical capabilities, fostering a culture of continuous improvement and evidence-based territorial management. By linking operational workflows with clearly defined roles, responsibilities, and communication channels, monitoring outputs become both technically rigorous and actionable, supporting timely policy interventions and informed decision-making across multiple territorial scales.

Ultimately, this structured yet adaptive methodology underpins the production of indicators that can feed a dynamic REOT, providing a consistent framework for ongoing monitoring while accommodating local specificities and ensuring national comparability. The expected outcome is a system that balances standardization and flexibility, enabling municipalities of varying capacities to participate effectively while progressively strengthening the national monitoring infrastructure.

5.6. Lessons Learned from the Cascais Experience

The pilot implementation undertaken in the Municipality of Cascais provides several lessons for the future development of Dynamic REOT systems in Portugal. First, it demonstrates that the technological infrastructure required to support dynamic monitoring already exists and can be implemented using commercially available business intelligence platforms integrated with existing municipal information systems. Second, it confirms that the principal implementation barriers are organisational rather than technological, particularly regarding data governance, information standardisation, historical data consistency and administrative interoperability. Third, it shows that indicator development should follow an incremental strategy, progressively expanding according to data quality and institutional maturity instead of attempting to produce exhaustive monitoring frameworks

from the outset. Finally, the pilot reinforces the central premise of this paper: the production of a Dynamic REOT should be understood not as the automation of report writing but as the outcome of a permanent territorial monitoring process supported by continuously updated administrative information.

6. Discussion, Conclusions, and Future Work

The conceptual framework proposed in this study is complemented by the pilot implementation developed within the Municipality of Cascais, allowing several of its fundamental methodological assumptions to be explored in practice. Although the pilot does not constitute a Dynamic REOT, it demonstrates that municipal administrative information can be continuously integrated into a Planning Support System capable of automatically producing planning indicators and supporting on-demand monitoring. This empirical contribution strengthens the proposed methodological framework by demonstrating that its core principles can be implemented using existing municipal information systems while simultaneously revealing that the principal challenges concern data governance, information standardisation and institutional organisation rather than technological availability.

This perspective is consistent with the evolution of Planning Support Systems (PSS), which have progressively developed from stand-alone analytical tools into integrated environments supporting collaborative, evidence-based, and adaptive planning [1,7,34]. More recently, Planning Support Science has argued that planning support should facilitate continuous learning, institutional adaptation, and evidence-informed governance rather than simply providing analytical capabilities [31]. The Dynamic REOT follows this direction by integrating territorial monitoring into the institutional planning cycle while preserving the statutory function of the REOT.

The proposed framework also reflects recent developments in Planning Analytics, which advocate the systematic use of continuously updated spatial information to improve planning processes and decision-making [38]. Similarly, Vonk [39] demonstrated that the effectiveness of Planning Support Systems depends not only on technological sophistication but also on their integration within planning practice and institutional workflows. The Dynamic REOT addresses precisely this challenge by reorganising territorial monitoring as a permanent operational activity rather than a reporting exercise carried out at predefined intervals. The Cascais Experience provides initial empirical evidence supporting this proposition. One of its principal findings is that the barriers to implementation are predominantly organisational rather than technological. Existing business intelligence platforms already provide the functionality required to aggregate, visualise and analyse municipal administrative information. However, transforming administrative databases into reliable monitoring systems requires substantial effort in data cleaning, standardisation, categorisation and historical harmonisation. Consequently, the successful implementation of a Dynamic REOT depends less on software development than on robust institutional information governance.

This interpretation is further supported by recent research on Smart Cities and digital planning. Geertman et al. [34], argues that planning support environments should move beyond technology-centred approaches and instead strengthen evidence-based governance through integrated territorial information systems. Likewise, the People-Centered Smart Cities framework promoted by UN-Habitat emphasises that digital transformation should primarily enhance transparency, institutional learning, participation, and decision quality rather than merely introducing new technological tools. In this respect, the Dynamic REOT is conceived as a governance-support framework where the monitoring dashboard functions as the operational environment for continuously maintaining territorial indicators, while the REOT itself represents an on-demand assessment of territorial conditions.

The proposed approach is also aligned with international territorial monitoring initiatives. ESPON has consistently highlighted the importance of harmonised territorial indicators and comparable monitoring systems capable of supporting territorial cohesion policies across multiple governance levels [6,40,41]. Similarly, the OECD Regional Development Outlook emphasises that integrated territorial information systems are becoming fundamental for regional resilience, policy coordination, and evidence-based investment decisions [41–45]. These international experiences reinforce the rationale underlying the Dynamic REOT by demonstrating that continuous territorial monitoring constitutes a prerequisite for adaptive territorial governance.

Recent research further confirms this tendency. Zhang et al. [44], analysing global land-use dynamics in relation to the Sustainable Development Goals, demonstrate that adaptive territorial policies increasingly depend on continuously updated spatial evidence capable of capturing rapidly evolving territorial processes. Although developed within a different analytical context, their conclusions reinforce the central premise of this study: territorial evaluation should progressively evolve from isolated reporting exercises towards continuous evidence generation capable of supporting adaptive public policies.

Unlike conventional Planning Support Systems, however, the Dynamic REOT does not propose a new planning instrument, a new indicator framework, or a new decision-support platform. Its principal contribution is methodological, demonstrating how an existing statutory planning instrument may be reconceptualised through continuous monitoring while maintaining its legal and institutional role within the Portuguese Territorial Management System. The Cascais Experience reinforces this contribution by showing that such a transformation can be initiated using existing municipal administrative information and commercially available business intelligence tools. Consequently, the originality of this work lies not in developing new technologies but in redefining the relationship between monitoring and reporting, transforming the REOT from a periodically produced document into the documentary expression of an ongoing territorial monitoring process.

6.1. *Dynamic REOT in an International Context*

Although the Dynamic REOT has been conceived within the specific legal and institutional framework of the Portuguese Territorial Management System, its underlying principles are consistent with broader international developments in territorial monitoring and evidence-based planning. Over the last two decades, several countries and international organisations have progressively shifted from periodic territorial reporting towards continuous monitoring systems supported by interoperable geospatial data infrastructures, harmonised indicators, and digital planning platforms.

Within the Planning Support Systems (PSS) literature, this evolution reflects a broader transition from analytical decision-support tools towards integrated planning environments capable of supporting continuous learning, adaptive governance, and evidence-informed decision-making [1,7,31]. Similarly, Planning Analytics advocates the continuous integration of territorial information into planning processes, enabling planning authorities to respond more effectively to rapidly changing territorial dynamics [38]. Rather than considering monitoring as an activity undertaken only when a report is required, these approaches promote the continuous production and maintenance of territorial evidence.

Comparable developments can also be observed in territorial governance initiatives promoted by international organisations. ESPON has established European territorial monitoring frameworks based on harmonised indicators that support territorial cohesion policies across multiple governance levels. Likewise, the OECD has highlighted the strategic role of integrated territorial information systems in improving regional resilience, policy coordination, and evidence-based public investment through its Regional Development Outlook. In

parallel, the UN-Habitat People-Centered Smart Cities framework emphasises that digital transformation should strengthen governance, transparency, institutional learning, and citizen-centred decision-making rather than focusing solely on technological innovation.

Several European countries have incorporated these principles into their territorial governance practices through permanent territorial observatories, national geospatial infrastructures, and continuously updated spatial indicator systems. Although these initiatives differ in their institutional organisation and legal responsibilities, they share a common objective: replacing isolated reporting exercises with continuous territorial monitoring capable of supporting adaptive planning and policy evaluation.

The Dynamic REOT aligns with this international evolution but differs in one fundamental aspect. Rather than proposing the creation of a new territorial observatory or an additional monitoring instrument, it reconceptualises an existing statutory planning instrument. The REOT remains the legally required evaluation report; however, its production is no longer based on a periodic reconstruction of territorial information but on the documentary extraction of evidence continuously maintained within a monitoring dashboard. This methodological reinterpretation allows the Portuguese Territorial Management System to benefit from contemporary planning support approaches while preserving its existing legal and institutional framework.

6.2. Limitations

The practical implementation of the proposed framework depends primarily on institutional capacity rather than technological availability. Municipalities exhibit considerable differences regarding technical resources, data governance practices, organisational maturity, and financial capacity, which may limit the homogeneous adoption of continuous monitoring systems. Likewise, effective implementation requires harmonised territorial indicators, interoperable databases, and stable mechanisms for horizontal and vertical coordination among public administrations.

The empirical validation presented in this study is also subject to limitations. The Cascais Experience was intentionally restricted to the urban planning management domain and therefore does not cover the complete thematic scope required by a statutory REOT. Furthermore, the dashboard was developed according to the availability and quality of municipal administrative information rather than a predefined national indicator framework. Consequently, the pilot should be interpreted as a proof of concept demonstrating the operational feasibility of the proposed methodology rather than as a complete implementation of a Dynamic REOT.

Another important limitation concerns the relationship between monitoring and evaluation. Continuous monitoring provides updated evidence regarding territorial dynamics but does not automatically constitute continuous evaluation. Evaluation requires appropriate temporal intervals that allow territorial transformations to consolidate, enabling meaningful comparisons between planning objectives and observed outcomes. Therefore, the Dynamic REOT should be understood as supporting evaluation rather than replacing it.

6.3. Scalability and Transferability

The conceptual framework is potentially transferable to other territorial contexts because it is independent of specific software platforms and is based on general principles of continuous territorial monitoring, indicator harmonisation, and evidence-based governance. Its implementation may therefore be adapted to municipalities with different institutional capacities, provided that interoperable territorial information systems and common indicator frameworks are available. Furthermore, extending the framework to in-

termunicipal, regional, and national levels would facilitate multilevel territorial monitoring and improve policy coordination across governance scales.

The Cascais Experience also suggests that scalability depends primarily on institutional maturity rather than municipal size. Since the proposed framework relies on administrative information routinely generated by municipal planning services, its implementation may progressively evolve according to the quality of local information systems, allowing municipalities to expand their monitoring capabilities incrementally rather than through large-scale technological investments.

6.4. Practical Implications

From a practical perspective, the Dynamic REOT provides a new interpretation of territorial monitoring within the Portuguese planning system. Instead of periodically reconstructing territorial evidence for each reporting cycle, municipalities may progressively maintain updated indicators through a permanent monitoring dashboard from which statutory REOTs can be generated whenever required. This approach reduces duplication of work, improves data consistency, strengthens institutional learning, and provides decision-makers with continuously updated territorial evidence capable of supporting adaptive planning practices.

The pilot implementation confirms that such an approach can be adopted incrementally. Rather than attempting to automate the entire REOT from the outset, municipalities may progressively develop thematic monitoring dashboards according to organisational priorities and data availability. This incremental strategy reduces implementation risks while simultaneously improving information quality and institutional learning.

6.5. Future Work

Future research should focus on extending and validating the proposed framework beyond the pilot implementation presented in this study. Although the Cascais Experience demonstrates the feasibility of integrating municipal administrative information into a dynamic monitoring dashboard, future developments should expand this approach to encompass the complete thematic scope of the REOT. Particular attention should be given to the definition of harmonised national indicator frameworks, interoperability between municipal information systems, automated report generation, dashboard usability, and institutional adoption across municipalities with different organisational capacities. Additional research may also explore predictive territorial indicators, scenario analysis, Digital Twins and advanced artificial intelligence techniques capable of strengthening strategic planning while preserving the REOT's primary role as a statutory territorial monitoring instrument.

6.6. Final Considerations

This study addressed one of the main challenges associated with territorial planning evaluation in Portugal: the static and episodic production of the State of Territorial Planning Report (Relatório do Estado do Ordenamento do Território—REOT). Although the REOT constitutes the principal statutory instrument for monitoring and evaluating territorial public policies, its current production model remains largely dependent on periodic data collection, manual processing, and the preparation of static reports. Consequently, the information available to decision-makers often reflects past territorial conditions rather than the current state of territorial dynamics, limiting the capacity of the REOT to support adaptive planning and evidence-based governance.

Rather than proposing a new territorial planning instrument or replacing the existing legal framework, this study presents a conceptual and methodological reinterpretation of the REOT production process. The central contribution consists of shifting the focus from

the periodic production of a report towards the continuous maintenance of a territorial monitoring environment. Within this framework, the REOT is no longer understood as the mechanism through which territorial information is collected and organised, but as the documentary output of an ongoing monitoring process based on continuously updated indicators. This conceptual change preserves the legal and institutional role of the REOT while significantly improving its operational value for territorial planning.

The proposed Dynamic REOT introduces a different perspective on territorial monitoring by integrating continuously updated territorial indicators into a permanent dashboard environment capable of supporting the day-to-day management of territorial information. Consequently, the preparation of a REOT no longer requires the reconstruction of the entire monitoring process at predefined intervals. Instead, the report can be generated whenever required, providing an updated assessment of territorial conditions and of the implementation of territorial public policies. This approach strengthens transparency, improves institutional learning, reduces duplication of technical work, and increases the responsiveness of planning authorities to rapidly evolving territorial dynamics.

From a scientific perspective, this study contributes to the international literature on Planning Support Systems by extending their application beyond conventional modelling, visualisation, and scenario analysis. While most Planning Support Systems are designed to support planning activities through analytical and decision-support capabilities, the Dynamic REOT demonstrates how the principles of continuous monitoring and evidence-based planning can be incorporated into an existing statutory planning instrument. In this respect, the proposed framework represents a methodological contribution rather than a technological one, illustrating how continuous monitoring can modernise territorial evaluation without requiring fundamental changes to the institutional architecture of the Portuguese Territorial Management System.

The proposed framework is also consistent with recent international developments promoting adaptive territorial governance based on continuously updated territorial evidence. International initiatives developed by organisations such as ESPON, the OECD, and UN-Habitat increasingly emphasise the importance of harmonised territorial indicators, integrated information systems, and continuous monitoring as fundamental components of effective territorial governance. Similarly, recent advances in Planning Support Science advocate the integration of monitoring, institutional learning, and evidence-based decision-making into planning practice. The Dynamic REOT aligns with these international trends while adapting them to the specific legal and institutional context of Portuguese territorial planning.

Nevertheless, the implementation of the proposed framework presents several challenges. The successful adoption of a Dynamic REOT depends on the availability of harmonised territorial indicators, interoperable spatial information systems, institutional coordination across different governance levels, and adequate technical capacity within public administrations. Furthermore, continuous monitoring should not be confused with continuous evaluation. Monitoring provides the information necessary to understand territorial dynamics, whereas evaluation requires appropriate temporal intervals that allow the impacts of territorial policies to become observable and comparable. Consequently, the Dynamic REOT should be understood as a mechanism that strengthens evaluation rather than replacing the critical assessment that characterises the REOT itself.

The practical implications of this study extend beyond the Portuguese context. Although developed to address the specific characteristics of the Portuguese Territorial Management System, the proposed conceptual framework is sufficiently flexible to be adapted to other planning systems based on statutory territorial monitoring. The separation between continuous monitoring and report generation may contribute to improving

the efficiency, transparency, and comparability of territorial evaluation processes in different institutional settings, particularly where planning authorities are increasingly expected to support policy decisions through continuously updated territorial evidence.

Future research should concentrate on validating the proposed framework through its implementation in a real municipal context. The development of a pilot Dynamic REOT will enable the evaluation of the proposed monitoring architecture, the definition and harmonisation of territorial indicators, the design of operational dashboards, and the assessment of institutional adoption by municipal planning departments. Additional research may also explore the incorporation of predictive territorial indicators, scenario analysis, and advanced analytical techniques capable of strengthening strategic planning while preserving the REOT's primary role as an instrument for territorial evaluation.

In conclusion, this study argues that the future evolution of the REOT depends less on producing reports more frequently than on transforming the way territorial information is monitored and managed. The Dynamic REOT proposed herein represents a methodological evolution that redefines the relationship between monitoring and reporting by establishing continuous territorial monitoring as the foundation of territorial evaluation. Within this paradigm, the REOT ceases to be the starting point of the monitoring process and becomes its principal documentary expression, providing public administrations with an adaptive, transparent, and evidence-based instrument capable of supporting more effective territorial governance in an increasingly dynamic and complex planning environment.

In summary, this study demonstrates that the future evolution of the REOT depends less on producing reports more frequently than on establishing continuous territorial monitoring capable of generating updated evidence whenever required. The Cascais Experience confirms that this objective is technically feasible using existing municipal administrative information and commercially available business intelligence tools, while simultaneously demonstrating that the principal implementation challenges concern information governance, data quality and institutional organisation. Within this perspective, the REOT ceases to represent the beginning of the monitoring process and instead becomes its principal documentary output, reinforcing its strategic role as an instrument for adaptive, evidence-based and transparent territorial governance.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
GIS	Geographic Information Systems
PDM	Plano Diretor Municipal
PSS	Planning Support System
REOT	Relatório de Estado do Ordenamento do Território

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