An Applied Knowledge Circulation Framework for Environmental Management in Airport Operations

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Abstract:
Airport operations generate significant environmental pressures due to continuous activities, high passenger throughput, and large-scale construction and maintenance works. Among these pressures, environmental management-particularly solid waste management-poses persistent challenges in aligning operational practices with available knowledge and evolving regulatory frameworks. This challenge is especially evident in rapidly developing and transitional contexts, where environmental regulations may lag behind practical management needs.
This study proposes an applied knowledge circulation framework for environmental management in airport operations, aiming to bridge the gap between operational practice, environmental knowledge, and regulatory requirements. Drawing on principles of applied and practice-based research, the framework conceptualizes knowledge as a dynamic and iterative process that is continuously generated, adapted, and refined through real-world application. The proposed Knowledge Circulation Cycle integrates three core components: operational practice, available knowledge (including circular economy concepts and best practices), and the regulatory framework, forming a closed-loop system that supports learning and continuous improvement.
Rather than presenting a technical solution or detailed quantitative assessment, this paper focuses on methodological contribution by providing a structured approach for analyzing environmental management practices in airport operations. The framework is illustrated through an application to airport solid waste management using simplified environmental data, tables, and conceptual figures. The results demonstrate the potential of the proposed framework to support adaptive environmental management, evidence-informed decision-making, and governance improvement in airport operations.

Keywords: environmental management; knowledge circulation; airport operations; applied research framework; circular economy.
JEL Classifications: R 21, R41, O44, Q58.

1. Introduction

Airport infrastructure plays a critical role in national and regional transport systems, serving as a backbone for economic development, international connectivity, and social mobility. In many countries, including Vietnam and other emerging economies, airport systems are undergoing rapid expansion and modernization, involving large-scale investments, complex stakeholder coordination, and increasingly stringent environmental and safety requirements [1]. These developments have significantly increased the demands placed on infrastructure and environment managers, who are expected not only to deliver projects efficiently, but also to ensure sustainable operation, regulatory compliance, and long-term resilience [2].

Despite the growing complexity of airport infrastructure management, research in this field has largely evolved along fragmented lines. Existing studies tend to focus on specific dimensions such as construction project management, operational optimization, environmental impact mitigation, or technological innovation. While these contributions are valuable, they often fail to address a fundamental challenge faced by practitioners: the misalignment between real-world operational practices, available knowledge, and regulatory frameworks. In practice, infrastructure managers frequently encounter situations where established regulations are incomplete, outdated, or insufficiently detailed to address emerging challenges, particularly in areas related to environmental management, circular economy practices, and the adoption of new technologies.

This misalignment creates a critical gap between theory and practice. On the one hand, academic research often emphasizes methodological rigor, abstraction, and generalization, sometimes at the expense of contextual relevance. On the other hand, practitioners are compelled to make timely decisions under uncertainty, relying on a combination of experiential knowledge, partial regulatory guidance, and pragmatic risk management. As a result, valuable practical knowledge generated through real-world operations is rarely captured, systematized, or translated into transferable insights that can inform future practice or policy development.

In recent years, there has been growing recognition of the need for applied research approaches that explicitly engage with practice and acknowledge the role of practitioners as active contributors to knowledge creation. This shift is reflected in the development of practice-based research, applied doctoral programs, and knowledge-to-action frameworks across various disciplines. However, within the field of transport and airport infrastructure management, methodological frameworks that clearly articulate how knowledge circulates between practice, research, and regulation remain limited.

Against this background, the purpose of this paper is to propose an applied methodological framework for airport operations. The framework is grounded in the logic of applied doctoral research, where the primary objective is not the production of abstract theory, but the systematic transformation of practical experience into validated knowledge that can support decision-making, organizational learning, and policy improvement. Central to this approach is the concept of a Knowledge Circulation Cycle, which conceptualizes knowledge as a dynamic and iterative process linking three core elements: operational practice, existing knowledge, and the regulatory framework.

Unlike conventional research models that treat regulation as a fixed constraint and knowledge as an external input, the proposed framework emphasizes continuous interaction and feedback. Operational challenges generate questions and learning needs; existing knowledge provides analytical and conceptual tools; regulatory frameworks shape, but are also influenced by, emerging practices. Through this circulation process, effective practices can be identified, refined, and gradually institutionalized, while ineffective or risky approaches are filtered out.

This paper does not aim to present a technical solution, quantitative model, or comprehensive case study. Instead, it offers a methodological contribution by articulating a structured way of understanding and managing the relationship between practice, knowledge, and regulation in

airport infrastructure systems. An illustrative example from airport operations is used to demonstrate the applicability of the framework, without claiming empirical generalization.

2. Literature Review and Research Gap

2.1. Research on airport infrastructure management and transport systems

Research on airport infrastructure management has expanded significantly over the past decades, reflecting the growing complexity of airport systems and their critical role in transport networks. Existing studies have addressed a wide range of topics, including project delivery and construction management, operational efficiency, safety and security management, environmental impact mitigation, and infrastructure lifecycle planning.

Within the transport literature, airport infrastructure is often examined through specialized lenses, such as engineering optimization, financial performance, or regulatory compliance. These studies have contributed valuable insights into specific functional domains; however, they tend to treat management challenges as sectoral or technical problems, rather than as interconnected socio-technical processes. As a result, the interaction between operational practice, managerial knowledge, and regulatory frameworks is frequently implicit rather than analytically explicit.

Moreover, many studies assume relatively stable institutional and regulatory environments, which may not reflect the realities faced by airport operators in rapidly developing or transitional contexts. In such environments, infrastructure managers must continuously adapt to evolving policy priorities, emerging technologies, and changing societal expectations, often without comprehensive regulatory guidance.

2.2. Knowledge, learning, and practice in infrastructure management

Beyond sector-specific studies, a broader stream of literature has examined the role of knowledge, organizational learning, and practice in infrastructure and project-based industries. Research on knowledge management, learning organizations, and project-based learning emphasizes that much of the knowledge used in complex infrastructure systems is tacit, experience-based, and context-dependent.

In transport infrastructure management, knowledge is often generated through problem-solving in real operational settings rather than through formal research alone. Practical solutions are developed, tested, and refined through iterative processes involving multiple stakeholders. However, this form of practice-based knowledge is not always systematically captured or translated into transferable insights, leading to repeated learning cycles and fragmented institutional memory.

While these studies highlight the importance of learning and knowledge in infrastructure organizations, they often stop short of providing a structured methodological framework that explains how knowledge moves between practice, formal research, and regulatory systems. As a result, the process by which operational experience contributes to institutional improvement remains under-theorized.

2.3. Applied research and practice-based methodologies

In response to the limitations of traditional academic research in addressing real-world complexity, applied research and practice-based methodologies have gained increasing

attention across disciplines. These approaches emphasize engagement with practice, reflexivity, and the co-production of knowledge between researchers and practitioners.

Applied doctoral research, in particular, has been proposed as a means of bridging the gap between academic inquiry and professional practice. Rather than prioritizing theory development alone, applied doctoral approaches focus on generating knowledge that is directly relevant to professional contexts while maintaining analytical rigor through systematic reflection and methodological transparency.

Despite this growing interest, the application of applied research methodologies within the transport and airport infrastructure domain remains relatively limited. Existing studies often adopt applied methods implicitly, without clearly articulating the underlying methodological logic or its implications for knowledge creation and governance. This lack of explicit methodological framing makes it difficult to assess how applied research contributes to long-term learning and institutional development in transport systems.

2.4. Research gap identification

The review of existing literature reveals several interrelated gaps. First, while airport infrastructure management has been widely studied, most research focuses on isolated technical or managerial dimensions, offering limited insight into how knowledge, practice, and regulation interact as an integrated system. Second, although the importance of learning and practice-based knowledge is widely acknowledged, there is a lack of conceptual frameworks that systematically explain how such knowledge is generated, validated, and stabilized within infrastructure organizations.

Third, applied research methodologies are increasingly recognized as valuable, yet their role in transport infrastructure management is often under-specified. In particular, there is a need for methodological frameworks that can support decision-making and learning in contexts characterized by regulatory uncertainty and rapid technological change.

To address these gaps, this study proposes an applied methodological framework for airport operations. By conceptualizing knowledge as a dynamic process linking operational practice, available knowledge, and regulatory frameworks, the proposed approach provides a structured lens for analyzing how applied practices emerge, evolve, and contribute to institutional learning. This framework responds directly to the need for methodological clarity in applied transport research and complements existing technical and managerial studies by focusing on the underlying processes of knowledge circulation.

By focusing on the underlying processes of knowledge circulation, this study responds directly to the need for methodological clarity in applied transport research, a perspective that is highly consistent with contemporary practice-based and participatory action research approaches [3].

3. Applied Research Methodology in Airport Infrastructure Management

3.1. Distinguishing applied research from conventional academic research

In the field of transport and airport infrastructure management, conventional academic research has traditionally emphasized methodological rigor, formal modeling, and generalizable results. Such an approach plays an important role in advancing theory and analytical tools; however, it often encounters limitations when addressing complex, context-dependent problems faced by infrastructure operators in real-world settings.

Applied research adopts a different epistemological stance. Rather than seeking universal solutions, it focuses on practical relevance, contextual validity, and decision support. In applied research, knowledge is not treated as an abstract outcome detached from implementation, but as a product of continuous interaction between practice, analytical reasoning, and institutional constraints. This distinction is particularly significant in airport infrastructure management, where operational decisions must frequently be made under conditions of uncertainty, regulatory incompleteness, and competing technical, environmental, and organizational objectives.

Within this context, applied research does not replace academic rigor; instead, it redefines rigor in terms of systematic reflection on practice, transparency of reasoning, and structured learning from real-world application. The objective is not to eliminate contextual complexity, but to make it analytically visible and manageable.

3.2. Applied doctoral methodology as a practice-based research approach

The methodological foundation of this study is aligned with applied doctoral research, which positions the researcher as an active participant in the professional context under investigation. Unlike traditional doctoral research, where the researcher often maintains analytical distance, applied doctoral methodology explicitly recognizes the value of practitioner insight, experiential knowledge, and institutional learning.

In airport infrastructure management, practitioners frequently operate at the intersection of engineering requirements, regulatory obligations, and organizational constraints. As a result, applied doctoral research provides a suitable framework for systematically transforming professional experience into structured knowledge. This transformation is achieved through cycles of observation, analysis, implementation, and reflection, rather than through linear hypothesis testing alone.

Applied doctoral methodology is particularly appropriate in contexts where regulatory frameworks evolve more slowly than technological and operational practices. In such situations, practitioners are required to interpret existing regulations creatively, adapt knowledge from related domains, and manage risk proactively. Capturing and analyzing these processes requires a methodology that is both analytically robust and sensitive to practice.

Unlike traditional doctoral research, where the researcher often maintains analytical distance, applied doctoral methodology explicitly recognizes the value of practitioner insight, experiential knowledge, and institutional learning through engaged scholarship [4].

3.3. Role of the applied researcher in infrastructure management studies

Within the applied research framework, the researcher assumes multiple, interrelated roles. First, the researcher acts as a practice-informed observer, capable of identifying emerging operational challenges that may not yet be reflected in formal regulations or academic literature. Second, the researcher functions as a knowledge integrator, synthesizing insights from existing studies, professional guidelines, and experiential learning. Third, the researcher serves as a reflective analyst, evaluating the outcomes of applied practices and identifying patterns that can inform future decision-making and policy development.

In airport infrastructure management, this multi-role positioning enables the researcher to bridge the gap between operational realities and conceptual frameworks. Rather than viewing

regulatory constraints as static boundaries, the applied researcher examines how regulations are interpreted, operationalized, and sometimes extended through practice. This perspective is essential for understanding how new management practices emerge and how they may eventually contribute to institutional and regulatory evolution.

4. The Knowledge Circulation Cycle Framework

4.1. Conceptual foundations of the Knowledge Circulation Cycle

Building on the applied research methodology described above, this paper proposes the Knowledge Circulation Cycle as a conceptual framework for understanding how knowledge is generated, applied, and refined in airport infrastructure management. The framework is grounded in the assumption that knowledge is not a one-directional transfer from research to practice, but a dynamic and iterative process involving continuous feedback among multiple elements.

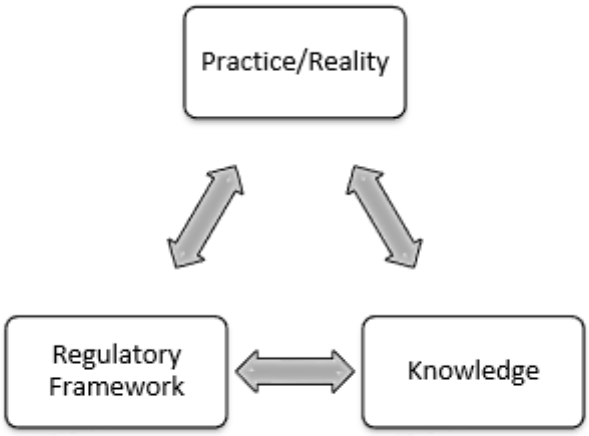

Figure 1. The Knowledge Circulation Cycle

The Knowledge Circulation Cycle consists of three core components: operational practice, available knowledge, and the regulatory framework. These components interact through iterative processes of problem identification, analysis, implementation, and evaluation. Together, they form a closed-loop system that supports learning, adaptation, and institutional improvement. In fact, the research has established foundational content, serving as a basis for developing and practicing further content in the future [5].

4.2. Core components of the Knowledge Circulation Cycle

4.2.1. Operational practice

Operational practice represents the real-world activities associated with the investment, operation, and management of airport infrastructure. This includes technical operations, environmental management, organizational coordination, and compliance activities. Operational practice serves as the starting point of the knowledge circulation process, as it is where practical challenges and decision-making dilemmas emerge.

In many cases, operational challenges arise in areas where existing guidelines are ambiguous or incomplete. These challenges generate the need for new interpretations, adaptations, or combinations of existing knowledge.

4.2.2. Available knowledge

Available knowledge encompasses scientific research, professional standards, technical guidelines, international experience, and accumulated organizational learning. This knowledge provides analytical tools and conceptual references for understanding and addressing operational challenges.

Within the Knowledge Circulation Cycle, knowledge is not applied mechanically. Instead, it is selectively interpreted and adapted to fit the specific operational and institutional context. This adaptive process is a key characteristic of applied research and distinguishes it from purely theoretical approaches.

4.2.3. Regulatory framework

The regulatory framework includes laws, regulations, standards, and administrative procedures governing airport infrastructure development and operation. Regulation plays a dual role within the cycle. On one hand, it establishes boundaries and constraints that shape permissible actions. On the other hand, it provides a reference point for evaluating the legitimacy and acceptability of applied practices.

Importantly, the framework recognizes that regulations are not static. Over time, effective practices may influence regulatory updates, while regulatory gaps may prompt temporary reliance on analogous rules or professional judgment.

4.3. Dynamics of the Knowledge Circulation Cycle

The interaction among operational practice, available knowledge, and the regulatory framework forms a continuous circulation process. Operational challenges trigger the search for relevant knowledge; knowledge informs the design of practical responses; regulatory considerations guide implementation and risk management; and the outcomes of applied practices generate feedback that informs future decisions.

Through repeated cycles, certain practices demonstrate effectiveness, feasibility, and regulatory acceptability. These practices may then be consolidated as organizational routines, disseminated as best practices, or incorporated into formal guidelines. Conversely, practices that prove ineffective or incompatible with regulatory expectations are gradually abandoned.

This selective mechanism ensures that the circulation of knowledge contributes not only to immediate problem-solving, but also to long-term institutional learning and governance improvement.

4.4. Methodological contribution of the framework

The primary contribution of the Knowledge Circulation Cycle lies in its ability to structure applied research without reducing contextual complexity. Rather than prescribing specific technical solutions, the framework provides a methodological lens through which practitioners and researchers can systematically analyze how knowledge moves between practice, regulation, and institutional learning.

For airport infrastructure management, this approach offers a practical tool for navigating regulatory uncertainty, integrating diverse knowledge sources, and supporting evidence-informed decision-making. At the same time, it provides a foundation for further empirical research, comparative studies, and methodological refinement across different transport sectors.

This perspective aligns directly with the established concept of Mode 2 knowledge production, which emphasizes that knowledge is increasingly generated within the context of application rather than purely within isolated academic disciplines [6].

4.5. Novelty and contribution of the study

The novelty of this study lies in the development of an applied knowledge circulation framework specifically tailored to environmental management in airport operations, with a particular focus on solid waste management under conditions of regulatory uncertainty. While previous studies on circular economy, environmental management, and airport sustainability have primarily emphasized technical solutions, performance indicators, or material flow analysis, this study shifts attention to the methodological process through which environmental knowledge is generated, interpreted, and operationalized in real-world airport contexts.

The proposed Knowledge Circulation Cycle differs from existing knowledge-to-action or circular economy models by explicitly integrating operational practice, available environmental knowledge, and the regulatory framework into a continuous and iterative process. In the context of airport operations, where environmental regulations often provide general principles rather than detailed operational guidance, the framework highlights how practitioners adapt environmental knowledge through pilot implementation, professional judgment, and internal governance mechanisms. This practice-based orientation represents a key methodological contribution beyond descriptive or technology-driven approaches commonly found in the literature.

Another important contribution of this study is its explicit consideration of regulatory gaps as an analytical component, rather than treating regulation solely as a static constraint. By examining how environmental management practices interact with existing regulations and identifying areas of partial implementation or ambiguity, the framework provides a structured way to analyze regulatory limitations and learning processes in applied environmental management. This perspective is particularly relevant for developing and transitional contexts, where institutional and regulatory systems are still evolving.

From an applied research perspective, the study contributes a methodological tool for practice-based environmental analysis that does not rely on extensive quantitative datasets. Through the use of illustrative tables and conceptual figures, the framework demonstrates how environmental management practices can be systematically analyzed, evaluated, and refined based on real operational experience. This approach enhances the relevance of the study for practitioners, policymakers, and applied researchers working in complex infrastructure systems such as airports.

Overall, the main contribution of this study is the articulation of a transferable and adaptable methodological framework that bridges environmental knowledge, operational practice, and regulatory governance. Although illustrated through airport solid waste management, the proposed Knowledge Circulation Cycle can be extended to other environmental management domains within transport infrastructure systems, providing a foundation for future empirical and comparative research.

5. Environmental Management Application of the Knowledge Circulation Cycle

5.1. Environmental management context in airport operations

Airport infrastructure systems generate a wide range of environmental pressures due to continuous operation, high passenger throughput, and large-scale construction and maintenance activities. Among these pressures, solid waste management represents a critical challenge, particularly in the context of terminal expansion, infrastructure upgrading, and daily airport operations. Waste streams at international airports typically include construction and demolition waste, municipal solid waste, hazardous waste, and green waste from landscaping activities.

Effective environmental management in airport operations requires not only technical solutions, but also the alignment of operational practices with available knowledge and the prevailing regulatory framework. In practice, airport operators often face situations where environmental regulations provide general requirements but lack detailed operational guidance tailored to the specific conditions of airport systems. This creates a need for adaptive management approaches that can integrate environmental knowledge, regulatory compliance, and real-world operational constraints.

To illustrate the environmental context addressed in this study, Table 1 presents an illustrative classification of typical solid waste streams generated in international airport operations, together with their main sources, treatment methods, and potential for circular economy application. The table does not aim to provide detailed quantitative assessment, but rather to establish a representative environmental management context for the application of the proposed methodological framework.

Table 1. Illustrative classification of solid waste streams at an international airport

Waste category	Main source	Typical treatment method	Circular economy potential
Construction and demolition waste	Terminal expansion, infrastructure maintenance	Recycling, disposal at licensed facilities	High
Municipal solid waste	Passenger terminals, office areas	Collection, treatment at municipal facilities	Medium
Hazardous waste	Equipment maintenance, technical operations	Specialized treatment by licensed contractors	Low
Green waste	Landscaping and green areas	Composting, on-site treatment	Medium

Note: The data presented in this table are illustrative and reflect typical waste streams observed in international airport operations. The purpose of the table is to demonstrate the applicability of the proposed framework rather than to provide detailed quantitative assessment.

5.2. Application of the Knowledge Circulation Cycle to airport waste management

The proposed Knowledge Circulation Cycle provides a structured methodological approach for addressing environmental management challenges in airport operations, particularly under

conditions of regulatory uncertainty and evolving sustainability requirements. When applied to solid waste management, the cycle begins with waste generation as an operational practice, which serves as the primary source of environmental pressure and management demand.

At this stage, airport operators draw upon available knowledge, including circular economy concepts, technical guidelines, international best practices, and accumulated organizational experience. This knowledge supports the identification of feasible waste management options, such as segregation at source, recycling of construction materials, and selective composting of green waste. However, the application of such knowledge must be carefully assessed in relation to the regulatory framework, which defines legal boundaries, compliance requirements, and accountability mechanisms.

In many cases, existing environmental regulations provide overarching principles but leave room for interpretation at the operational level. As a result, airport operators may implement waste management practices on a pilot or partial basis, relying on analogous regulations, professional judgment, and internal governance mechanisms. The interaction between applied practices and regulatory constraints often reveals gaps or ambiguities that require adaptive management responses.

This interaction is illustrated in Table 2, which highlights the alignment between selected waste management practices and the regulatory framework, as well as identified implementation gaps. The table demonstrates how the Knowledge Circulation Cycle facilitates systematic analysis of practice-regulation relationships, rather than treating regulatory limitations as fixed barriers to action.

Table 2. Alignment between waste management practices and regulatory framework in airport environmental management [7, 8]

Management practice	**Relevant regulatory reference**	**Implementation status**	**Identified regulatory gap**
Waste segregation at source	Environmental protection regulations	Partially implemented	Limited operational guidance
Recycling of construction waste	Construction and environmental standards	Pilot application	Lack of specific sectoral regulation
Hazardous waste handling	Hazardous waste management regulations	Fully implemented	High compliance cost
Green waste composting	Environmental management guidelines	Selective application	No unified technical standard

Note: The table illustrates the relationship between environmental management practices and the regulatory framework to support analysis of regulatory gaps within the Knowledge Circulation Cycle.

5.3. Feedback, learning, and continuous improvement

A defining feature of the Knowledge Circulation Cycle is the presence of feedback and learning mechanisms, which enable continuous improvement of environmental management practices. Following implementation, applied waste management measures are evaluated through operational monitoring, compliance review, and internal assessment processes. Practices that demonstrate effectiveness, feasibility, and regulatory acceptability are progressively refined and institutionalized within airport management systems.

Conversely, practices that generate excessive risk, operational inefficiency, or regulatory concern are modified or discontinued. Through repeated iterations of the cycle, airport operators develop a more robust understanding of how environmental knowledge can be operationalized within existing regulatory constraints. This learning process contributes not only to improved environmental performance, but also to organizational capacity building and governance enhancement.

The application of the Knowledge Circulation Cycle to airport waste management is summarized in Figure 2, which illustrates the interaction between waste generation, available knowledge, regulatory framework, applied practices, and feedback for improvement. The figure emphasizes that environmental management is not a linear process, but an iterative and adaptive cycle driven by real-world operational experience.

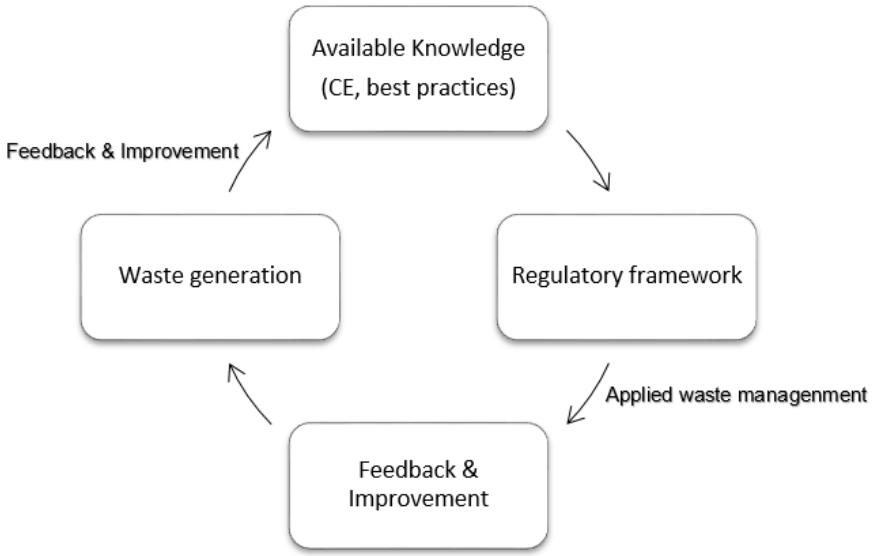

Figure 2. Application of the Knowledge Circulation Cycle to airport waste management.

The figure illustrates how solid waste generation in airport operations is addressed through the interaction between available knowledge (circular economy concepts and best practices), the regulatory framework, and applied waste management practices, with continuous feedback for improvement.

5.4. Methodological implications for environmental management research

The application presented in this section demonstrates how the proposed framework can be used to analyze environmental management challenges without relying on extensive quantitative datasets. Tables 1 and 2 and Figure 2 serve illustrative purposes, supporting methodological explanation rather than empirical generalization. This approach is particularly suitable for applied environmental research in complex infrastructure systems, where access to detailed data may be constrained by operational or institutional considerations.

By integrating environmental context, regulatory analysis, and practice-based learning within a single methodological framework, the Knowledge Circulation Cycle offers a practical tool for improving environmental management in airport operations. At the same time, it provides a foundation for future empirical studies that may seek to quantify environmental performance outcomes or compare applications across different airport systems.

This study adopts an applied research approach combining document analysis, expert knowledge, and illustrative operational data derived from airport environmental management practices.

6. Discussion: Implications for Transport Technology and Management

6.1. Implications for transport technology adoption

One of the key challenges in transport infrastructure systems, particularly in airport operations, lies not in the absence of technology, but in the difficulty of translating available technological knowledge into consistent and legitimate operational practice. New technologies related to environmental management, resource efficiency, and digitalization often emerge faster than the regulatory frameworks designed to govern their application. As a result, technology adoption is frequently constrained by uncertainty rather than technical infeasibility.

The Knowledge Circulation Cycle provides a methodological perspective that helps explain and manage this challenge. By framing technology adoption as part of an iterative process linking operational practice, knowledge, and regulation, the framework emphasizes gradual validation rather than immediate standardization. Technologies are first interpreted and adapted through practice, assessed in relation to existing regulatory principles, and refined through feedback mechanisms. Over time, those technologies that demonstrate operational value and regulatory acceptability are more likely to be institutionalized.

From a transport technology perspective, this approach shifts the focus away from one-off implementation toward learning-oriented deployment. It highlights the importance of organizational capability to absorb, interpret, and evaluate technology in context, rather than relying solely on formal compliance or technical specifications. This has particular relevance for airport infrastructure, where safety, reliability, and environmental performance must be balanced against innovation pressures.

6.2. Implications for infrastructure management practice

For infrastructure managers, the proposed framework offers a structured way to navigate decision-making under regulatory uncertainty. Rather than treating regulatory gaps as barriers to action, the Knowledge Circulation Cycle encourages managers to recognize such gaps as opportunities for structured learning and controlled experimentation, provided that appropriate governance mechanisms are in place.

By explicitly linking applied practices to available knowledge and regulatory considerations, the framework supports more transparent and defensible decision-making. Managers can articulate not only what actions were taken, but also why specific knowledge sources were selected, how regulatory risks were interpreted, and how outcomes were evaluated. This transparency is particularly important in public and semi-public infrastructure organizations, where accountability and institutional legitimacy are critical [9].

In addition, the framework supports organizational learning by emphasizing the selective retention of effective practices. Practices that demonstrate technical feasibility, operational efficiency, and regulatory compatibility are more likely to be formalized and disseminated within the organization. Over time, this contributes to the development of internal standards, shared professional understanding, and improved management capability across projects and operational units [10].

6.3. Implications for regulatory development and governance

The Knowledge Circulation Cycle also has implications for regulatory development in the transport sector. Traditional regulatory approaches often assume a linear relationship in which regulations precede practice and prescribe acceptable behavior. In reality, particularly in technologically dynamic environments, practice frequently evolves ahead of formal regulation. By making this dynamic explicit, the proposed framework highlights the role of applied practice as a source of regulatory insight. Effective operational practices, once systematically documented and evaluated, can inform regulatory refinement and policy development. This does not imply bypassing regulatory authority, but rather strengthening the evidence base upon which regulatory decisions are made.

For regulators and policymakers, understanding how knowledge circulates within infrastructure organizations can improve the design of adaptive and responsive regulatory instruments. The framework suggests that regulation should not only constrain behavior, but also facilitate learning by recognizing provisional practices, encouraging feedback, and supporting gradual standardization where appropriate.

6.4. Implications for applied research and professional training

Beyond its immediate relevance to infrastructure management, the proposed framework contributes to the broader discussion on applied research and professional training in the transport sector. In applied doctoral and professional education programs, there is often a need for methodological approaches that bridge academic inquiry and professional practice.

The Knowledge Circulation Cycle provides such an approach by offering a structured yet flexible methodology for practice-based research. It enables practitioners to engage in systematic inquiry without requiring extensive quantitative datasets or experimental conditions that may be impractical in operational environments. At the same time, it maintains analytical rigor through explicit reflection on knowledge sources, decision processes, and outcomes.

For training institutions and research organizations, the framework can serve as a foundation for developing curricula and research designs that are closely aligned with industry needs. It supports the development of reflective practitioners who are capable of generating, evaluating, and applying knowledge within complex institutional settings.

6.5. Contribution to transport management literature

From an academic perspective, this study contributes to the transport management literature by offering a methodological framework that integrates practice, knowledge, and regulation into a coherent analytical structure. Rather than focusing on specific technical solutions or performance metrics, the paper addresses a foundational question: how knowledge is created, circulated, and stabilized within transport infrastructure systems.

By articulating this process, the Knowledge Circulation Cycle complements existing research on infrastructure governance, innovation management, and sustainability. It provides a conceptual bridge between empirical studies of operational practice and normative discussions of policy and regulation.

7. Conclusion

This paper addresses the persistent gap between real-world operational practices, available knowledge, and evolving regulations in the transport sector by proposing an applied methodological framework for airport operations. Rather than focusing on technical or quantitative solutions, the study offers a methodological perspective centered on the Knowledge Circulation Cycle. This cycle conceptualizes knowledge as a dynamic, iterative process linking operational practice, existing knowledge, and regulation. By framing infrastructure management challenges as learning opportunities rather than isolated problems, the framework provides a structured approach to analyze how practical applications emerge, gain legitimacy, and drive organizational development. This is highly relevant in environments with regulatory uncertainty and rapid technological change, enabling infrastructure managers to make transparent, evidence-informed decisions and achieve structured learning without relying heavily on quantitative data. Conceptually, it bridges practice-based research with infrastructure governance, shifting academic focus from isolated solutions to the processes of knowledge mobilization.

However, the study carries certain limitations: it prioritizes conceptual development over empirical generalization, meaning it lacks validation through detailed case studies or quantitative data, and its illustrative example serves only to demonstrate the framework's underlying logic. These limitations pave the way for future research directions. Future studies could empirically apply the framework to specific infrastructure projects using qualitative or mixed-method approaches to track actual knowledge circulation. Additionally, comparative research could test its adaptability across other transport sectors like road, rail, or maritime infrastructure. Future work could also integrate the framework with emerging themes such as digital transformation, data-driven management, and circular economy practices, or use it to design applied doctoral and professional training programs that cultivate reflective practitioners for sustainable infrastructure governance.

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