

Reconfiguring Multidimensional Dynamic Accounting for Sustainable Public Value Creation: Evidence from Intelligent Monorail Infrastructure

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Abstract

Purpose

This study aims to reconfigure multidimensional dynamic accounting as an integrated framework for measuring, creating, and enhancing sustainable value within smart mobility infrastructure projects in emerging economies. The research addresses the limitations of traditional accounting approaches that predominantly emphasize financial efficiency while neglecting strategic, social, environmental, governance, and digital dimensions of value generated by intelligent transportation systems. The study particularly examines how smart monorail infrastructure can operate as a dynamic platform for sustainable public value creation rather than merely a capital-intensive transportation asset.

Methodology, Design, and Approach

The study adopts a mixed-methods design integrating quantitative and qualitative approaches. Quantitatively, panel data analysis and structural modeling are employed using operational, financial, sustainability, governance, and urban mobility indicators associated with smart mobility infrastructure projects in selected emerging economies during the study period. Qualitatively, the study incorporates policy analysis, expert interviews, institutional reports, and comparative benchmarking of intelligent transport governance practices. A multidimensional Sustainable Integrated Value Index (SIVI) is developed to operationalize dynamic value creation across economic, environmental, digital, governance, and social dimensions.

Findings

The findings indicate that smart mobility infrastructure significantly contributes to sustainable value creation when supported by dynamic accounting integration, digital governance mechanisms, sustainability-oriented reporting, and institutional coordination. The results further reveal that multidimensional accounting models outperform conventional financial evaluation approaches in capturing long-term strategic public value. Additionally, digital integration and governance quality positively moderate sustainable value creation efficiency in emerging economies.

Originality and Value

This study introduces an innovative multidimensional dynamic accounting framework for sustainable infrastructure intelligence and develops a novel integrated index for measuring sustainable public value in smart mobility projects. The research contributes to bridging the gap between accounting theory, infrastructure governance, sustainability measurement, and intelligent urban transformation.

Theoretical, Practical, and Social Implications

The study extends accounting literature toward dynamic public value accounting and provides policymakers, regulators, and infrastructure planners with a strategic framework for evaluating intelligent transportation investments. Socially, the framework supports sustainable urban development, environmental resilience, accessibility, and quality-of-life enhancement in emerging economies.

Keywords

Dynamic accounting; Sustainable value creation; Smart mobility infrastructure; Public value; Sustainability accounting; Emerging economies; Intelligent transportation systems; Infrastructure governance.

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I. Reconfiguring Sustainable Infrastructure Intelligence: Research Foundations, Intellectual Tensions, and Strategic Problematization

1.1 The Global Transformation of Intelligent Infrastructure Ecosystems

The global transition toward digitally enabled and sustainability-oriented urban systems has fundamentally transformed the strategic role of infrastructure within contemporary governance environments. Infrastructure is no longer interpreted merely as a physical asset supporting transportation efficiency or operational connectivity. Instead, intelligent

mobility ecosystems increasingly function as integrated platforms through which governments coordinate sustainability transitions, digital governance capabilities, urban resilience, and long-term public value creation (Appio et al., 2023; Gao et al., 2024; Secundo et al., 2024). Within this evolving landscape, smart monorail systems represent more than transportation technologies; they constitute complex socio-technical infrastructures that continuously interact with governance institutions, digital platforms, environmental systems, and urban development strategies.

This transformation has significantly expanded the nature of value generated by infrastructure investments. Contemporary intelligent infrastructure ecosystems create value simultaneously across economic, environmental, social, governance, and digital dimensions. Their contribution extends beyond transportation performance toward congestion mitigation, environmental optimization, accessibility enhancement, climate resilience, institutional coordination, and quality-of-life improvement. Consequently, infrastructure value increasingly emerges as a dynamic and multidimensional phenomenon generated through continuous interactions among technology, governance capability, sustainability objectives, and societal outcomes rather than through isolated operational activities (Scobie et al., 2024; Adams et al., 2024).

Despite this transformation, accounting systems have evolved at a considerably slower pace. Most existing infrastructure accounting frameworks remain conceptually rooted in industrial-era assumptions emphasizing expenditure control, asset utilization, depreciation structures, and retrospective financial accountability. While these dimensions remain important, they provide only a partial explanation of how intelligent infrastructure ecosystems create sustainable value over time. Traditional accounting architectures were developed primarily to monitor financial performance rather than to capture dynamic sustainability outcomes, governance capability, resilience generation, or public value creation processes (Lodhia et al., 2024; Bebbington et al., 2024; Adams & Abhayawansa (2022)

As a result, an important intellectual tension has emerged across contemporary literature. Infrastructure systems are increasingly expected to function as intelligent sustainability ecosystems, while accounting systems continue to evaluate them through relatively static financial measurement logics. Sustainability research has begun to advocate the integration of environmental, governance, and social intelligence into accounting architectures, whereas governance scholarship increasingly emphasizes predictive decision-making, digital accountability, and AI-enabled coordination mechanisms (Bracci et al., 2024; Arena et al., 2023; Farneti et al., 2023; de Villiers et al., 2024). However, these streams of literature remain largely fragmented. Sustainability accounting studies frequently concentrate on disclosure and reporting practices, while infrastructure research often prioritizes engineering efficiency and technological modernization without adequately addressing the accounting mechanisms required to govern sustainable value creation.

The present study argues that this fragmentation reflects a deeper conceptual problem. As intelligent mobility ecosystems become strategic instruments for urban transformation and sustainable development, accounting can no longer remain a purely retrospective reporting mechanism. Instead, it must evolve into an integrated sustainability intelligence architecture capable of supporting governance coordination, predictive decision-making, resilience management, and sustainable public value optimization. Accordingly, the study positions accounting as a strategic governance capability embedded within intelligent infrastructure ecosystems and proposes a multidimensional dynamic accounting perspective capable of explaining how sustainable public value is created, coordinated, and sustained within smart monorail infrastructures operating in rapidly transforming urban environments.

1.2 Problematising Infrastructure Accounting in Emerging Economies

Although intelligent mobility infrastructures have expanded rapidly across emerging economies, existing accounting architectures remain structurally constrained in their ability to capture and coordinate sustainable multidimensional value creation. Most infrastructure evaluation systems continue to focus predominantly on capital expenditure, utilization rates, operational efficiency, and financial performance indicators. While these measures remain relevant, they provide limited insight into how intelligent mobility ecosystems generate broader forms of value associated with environmental sustainability, governance modernization, digital integration, urban resilience, and long-term societal welfare.

This limitation gives rise to what the present study conceptualizes as the Sustainable Infrastructure Value Visibility Problem. The problem refers to the growing disconnect between the multidimensional value created by intelligent infrastructure ecosystems and the narrow financial logic through which such value is traditionally assessed. Smart monorail systems generate substantial benefits through congestion reduction, accessibility enhancement, environmental optimization, predictive operational resilience, and digital governance integration. Yet many of these outcomes remain either weakly represented or entirely invisible within conventional accounting systems because existing frameworks were not designed to capture dynamic ecosystem-based value creation processes.

The challenge becomes particularly significant within emerging economies where infrastructure projects frequently operate under conditions characterized by institutional fragmentation, uneven digital capability, governance asymmetry, and sustainability transition pressures (Gerged et al., 2023; Boiral et al., 2024; Di Vaio et al., 2024). Under such circumstances, sustainable infrastructure performance depends not only on physical assets and technological sophistication but also on governance capability, institutional quality, digital accountability, and predictive operational intelligence. Consequently, the study argues that traditional infrastructure accounting systems require substantial conceptual transformation if they are to remain relevant within increasingly intelligent and sustainability-oriented governance environments (Kaur et al. (2024)

1.3 Research Objectives, Research Questions, and Substantive Importance of the Study

Against this background, the present study seeks to develop and empirically examine a multidimensional dynamic accounting framework capable of explaining how intelligent mobility ecosystems create sustainable public value within emerging economies. More specifically, the study aims to reposition accounting from a traditional infrastructure costing mechanism toward a Dynamic Public Value Accounting architecture capable of integrating sustainability intelligence, governance capability, AI-enabled operational analytics, and long-term value optimization (Dumay et al., 2023)

To achieve this objective, the study pursues four interrelated goals. First, it critically evaluates the limitations of conventional infrastructure accounting systems in capturing sustainable multidimensional value. Second, it develops a Multidimensional Dynamic Accounting (MDA) framework capable of integrating governance, sustainability, digital intelligence, and public value dimensions within a unified analytical architecture. Third, it introduces the Sustainable Integrated Value Index (SIVI) as a multidimensional measurement model designed to assess infrastructure performance across economic, environmental, social, governance, digital, and urban dimensions. Finally, it investigates how governance capability, institutional quality, sustainability disclosure quality, and AI-enabled operational intelligence influence sustainable public value creation within smart monorail ecosystems Rinaldi et al. (2024)

Accordingly, the study addresses the following research questions:

1. How do intelligent mobility ecosystems challenge the conceptual assumptions underlying traditional infrastructure accounting systems?
2. To what extent can multidimensional dynamic accounting improve sustainable public value measurement and governance coordination within smart infrastructure ecosystems?
3. How do governance capability, institutional quality, and AI-enabled operational intelligence influence sustainable public value creation within intelligent mobility systems?
4. How can accounting systems evolve from retrospective financial reporting mechanisms toward predictive sustainability intelligence architectures?
5. How can smart monorail infrastructure systems contribute to long-term sustainable public value creation within emerging economies?

The importance of the study derives from its attempt to address a critical gap at the intersection of sustainability accounting, governance intelligence, public value theory, and intelligent infrastructure research. Existing accounting systems remain largely incapable of capturing the full spectrum of value generated by contemporary infrastructure ecosystems. Consequently, substantial dimensions of sustainable public value remain accounting-invisible. By introducing Dynamic Public Value Accounting and the Sustainable Integrated Value Index, the study contributes to the ongoing reconfiguration of accounting thought within digitally enabled and sustainability-oriented governance environments. Practically, the proposed framework offers policymakers, infrastructure authorities, and governance institutions a multidimensional mechanism for supporting sustainability-oriented decision-making, predictive operational intelligence, infrastructure resilience, and long-term public value optimization.

II. Reframing the Knowledge Landscape of Sustainable Infrastructure Intelligence: Critical Literature Synthesis and Intellectual Positioning

2.1 From Infrastructure Costing to Sustainable Infrastructure Intelligence

Infrastructure accounting has historically been dominated by a cost-centered paradigm emphasizing capital expenditure, depreciation, budgetary control, operational efficiency, and financial stewardship. While such mechanisms remain important for accountability and resource allocation, they are increasingly inadequate for explaining how contemporary intelligent infrastructure systems create sustainable value across economic, environmental, social, governance, and digital dimensions. Recent sustainability accounting research argues that accounting systems must evolve beyond retrospective financial measurement toward more integrated architectures capable of supporting sustainability-oriented governance and long-term public value creation (Adams & Abhayawansa, 2022; Bebbington et al., 2024).

The emergence of smart mobility infrastructure has accelerated this challenge. Intelligent transport systems operate as digitally connected ecosystems in which value is generated not only through physical assets but also through data integration, AI-enabled operations, governance coordination, environmental optimization, and citizen engagement (Secundo et al., 2024; Gao et al., 2024; Larrinaga et al., 2024). Consequently, the traditional focus on infrastructure costs and utilization rates provides only a partial representation of infrastructure performance because substantial dimensions of value remain outside conventional accounting visibility.

This issue is particularly relevant within emerging economies where large-scale infrastructure projects are frequently evaluated through engineering completion and financial feasibility while broader sustainability outcomes remain weakly measured. Smart monorail systems, for example, may improve accessibility, reduce congestion, support low-carbon mobility, enhance digital governance, and strengthen urban resilience. However, many of these benefits remain accounting-invisible because they do not appear directly within traditional reporting systems (Mazzucato & Kattel, 2023; Rinaldi et al., 2024; Alkaraan et al. (2024).

Recent integrated reporting and sustainability accounting literature has attempted to broaden the meaning of value by incorporating financial, social, human, intellectual, and natural capitals (Lai et al., 2023; Vitolla et al., 2023). Nevertheless,

much of this literature remains organization-centered and insufficiently addresses public infrastructure ecosystems characterized by institutional complexity and multidimensional value creation. Accordingly, this study argues that the appropriate conceptual transition is not simply from financial reporting to ESG disclosure, but from infrastructure costing to sustainable infrastructure intelligence. Under this perspective, accounting evolves into a strategic capability for measuring, interpreting, and coordinating sustainable value creation across intelligent infrastructure ecosystems Parker & Northcott (2024).

2.2 Intelligent Mobility Ecosystems and Public Value Creation

The rise of intelligent mobility ecosystems has fundamentally transformed the nature of transportation infrastructure. Smart mobility no longer refers solely to technological modernization; rather, it encompasses digitally integrated ecosystems supported by real-time monitoring, AI analytics, predictive maintenance, sustainability-oriented governance, and continuous user interaction (Appio et al., 2023; Corsi et al., 2024; Zhao et al. (2024). These systems are designed not only to improve mobility efficiency but also to enhance urban sustainability, social inclusion, environmental performance, and public-sector responsiveness.

This transformation significantly alters the accounting challenge. If intelligent mobility systems function as ecosystems rather than isolated assets, accounting systems must capture how value emerges through interactions among governments, operators, technology providers, regulators, urban planners, and citizens. Public value is therefore co-created through institutional coordination rather than generated by a single organizational actor. This perspective aligns closely with contemporary public value theory, which evaluates infrastructure according to broader societal outcomes rather than narrow efficiency indicators (Mazzucato & Kattel, 2023; Choi et al., 2024; Biondi et al. (2024).

Within smart mobility environments, value creation occurs across multiple dimensions simultaneously. Economically, intelligent transport systems improve productivity through reduced travel time and enhanced labor market connectivity. Environmentally, they contribute to lower emissions and more sustainable urban mobility patterns. Socially, they improve accessibility and reduce spatial exclusion. Digitally, they generate operational intelligence capable of enhancing planning, resilience, and service quality. From a governance perspective, they strengthen transparency, monitoring capability, and accountability mechanisms. These dimensions are deeply interconnected and cannot be adequately represented through isolated financial measures (Gürdür Broo et al., 2023).

Despite growing interest in smart mobility, the literature remains fragmented. Transport studies primarily emphasize efficiency and environmental outcomes, while smart city research focuses on digital platforms and technological innovation. Sustainability accounting studies frequently concentrate on ESG disclosure, whereas governance literature prioritizes accountability and institutional performance. Few studies integrate these streams within a coherent accounting framework capable of explaining how intelligent infrastructure systems generate and sustain multidimensional public value over time. This gap provides a central foundation for the present study, which positions intelligent mobility infrastructure as a sustainable public value ecosystem and accounting as a strategic mechanism for coordinating its long-term value creation processes (Pizzi et al. ,2023).

2.3 Sustainability Intelligence Beyond ESG Disclosure

Sustainability accounting literature has substantially expanded the informational boundaries of accounting by incorporating environmental, social, and governance concerns into reporting and accountability systems. However, much of this development remains constrained by a disclosure-centered logic in which sustainability accounting primarily operates as a mechanism for external communication, legitimacy, and stakeholder reporting rather than as an embedded governance architecture for coordinating sustainable transformation (Adams & Abhayawansa, 2022; Tommasetti et al., 2020). This limitation becomes especially problematic in smart infrastructure contexts, where sustainability value is not produced through disclosure alone but through continuous interaction among operational data, governance coordination, environmental performance, predictive analytics, and public value creation.

Within intelligent mobility ecosystems, ESG disclosure is necessary but insufficient. Smart monorail systems generate sustainability effects through reduced congestion, lower emissions, accessibility improvement, predictive maintenance, digital passenger integration, and urban resilience. These effects are dynamic, operational, and institutionally embedded; therefore, they cannot be adequately captured by static ESG reporting templates. The literature on digitalization and accountability indicates that contemporary public-sector accounting increasingly depends on data production, data consumption, and the ability of accounting systems to transform digital information into actionable accountability mechanisms (Agostino et al., 2022;] Albitar et al. (2024; Eccles & Klimenko (2019). Accordingly, sustainability accounting must evolve from static disclosure toward sustainability intelligence.

Sustainability intelligence refers to the ability of accounting systems to integrate sustainability metrics, digital operational data, governance indicators, and forward-looking analytical tools into decision-making processes. This perspective is consistent with recent arguments that digital technologies and artificial intelligence are reshaping sustainability governance by enabling prediction, coordination, and real-time accountability rather than merely improving reporting efficiency (Di Vaio et al., 2020; de Villiers et al., 2025; Humphrey et al. (2024). The present study therefore argues that smart mobility infrastructure requires accounting systems capable of supporting sustainability coordination, not

only sustainability representation. This shift is central to the proposed multidimensional dynamic accounting framework, because it positions accounting as a strategic mechanism for governing sustainable public value rather than as a passive record of financial or ESG information.

2.4 Governance Intelligence and Institutional Integration

The increasing complexity of intelligent infrastructure ecosystems has also transformed the meaning of governance. Traditional governance systems depend heavily on hierarchical oversight, periodic reporting, and retrospective control. By contrast, smart mobility systems require governance intelligence: the capacity to coordinate real-time operational information, digital accountability mechanisms, AI-enabled analytics, institutional decision-making, and sustainability priorities within an integrated governance architecture. This is particularly important in public infrastructure, where value is co-created by multiple actors, including government agencies, operators, users, regulators, technology providers, and urban planning authorities Ntim (2023).

Digital governance literature suggests that public-sector transformation increasingly depends on the ability of institutions to use data and intelligent technologies to enhance responsiveness, transparency, service quality, and accountability. However, AI-enabled governance does not automatically generate public value. Evidence from public-sector AI research indicates that public trust, institutional readiness, and governance design strongly influence whether AI systems improve accountability or create new risks such as opacity, bias, and weak oversight (Aoki, 2020; Misuraca & van Noordt, 2020). Therefore, intelligent infrastructure governance requires institutional integration rather than technological modernization alone Aguilera et al. (2024).

In emerging economies, this issue becomes more significant because smart infrastructure projects often operate under fragmented institutional arrangements, uneven digital capabilities, and inconsistent sustainability governance. Under such conditions, digital transformation may increase complexity unless supported by accounting systems capable of translating operational and sustainability data into governance-relevant intelligence. The present study therefore conceptualizes accounting-enabled governance intelligence as the integration of multidimensional accounting, digital governance, institutional coordination, and predictive operational intelligence. This concept links sustainability accounting with infrastructure governance by showing that sustainable public value is created when accounting systems become embedded within decision-making, monitoring, and accountability processes Boiral et al. (2024).

Accordingly, governance intelligence represents a central bridge between sustainability accounting and smart infrastructure performance. It enables infrastructure systems to move beyond fragmented reporting toward integrated value coordination. This provides the theoretical basis for examining how digital governance capability and institutional quality strengthen the relationship between multidimensional dynamic accounting and sustainable public value creation in smart monorail infrastructure.

2.5 AI-Enabled Predictive Infrastructure Intelligence

Artificial intelligence has emerged as one of the most transformative forces shaping contemporary infrastructure governance. Unlike traditional information systems that primarily support reporting and operational monitoring, AI-enabled infrastructure systems possess the capability to generate predictive intelligence by identifying patterns, anticipating disruptions, optimizing resource allocation, and supporting adaptive decision-making processes. Consequently, intelligent infrastructure is increasingly evaluated according to its capacity not only to perform efficiently but also to anticipate future operational, environmental, and governance challenges.

Within smart mobility ecosystems, predictive intelligence represents a critical mechanism for enhancing infrastructure resilience and long-term sustainability. AI applications such as predictive maintenance, demand forecasting, passenger-flow optimization, anomaly detection, and real-time operational analytics enable infrastructure operators to move from reactive management toward proactive governance models. This transition is particularly significant because sustainable public value depends not only on infrastructure performance but also on the ability of institutions to maintain service continuity, minimize operational disruptions, and optimize resource utilization over time (Di Vaio et al., 2020; Aoki, 2020; Kliestik et al. (2024).

However, predictive intelligence should not be interpreted merely as a technological capability. Recent governance literature emphasizes that AI effectiveness depends heavily on institutional readiness, accountability mechanisms, data governance quality, and human oversight structures (Misuraca & van Noordt, 2020; Munoz et al. (2024; Kliestik et al.,2024). Therefore, AI-enabled infrastructure intelligence becomes valuable only when embedded within governance systems capable of transforming predictive insights into informed strategic action. From this perspective, accounting assumes a new role as an integrative mechanism connecting predictive analytics, sustainability objectives, governance accountability, and public value outcomes. This argument provides an important foundation for the present study, which conceptualizes AI-enabled intelligence as a complementary component of multidimensional dynamic accounting rather than as an independent technological solution.

2.6 Research Gaps and Intellectual Positioning

The preceding review reveals substantial fragmentation across infrastructure accounting, sustainability accounting, public value theory, governance intelligence, and smart mobility research. Existing infrastructure studies primarily focus on engineering efficiency, operational performance, and technological modernization. Sustainability accounting research largely concentrates on ESG disclosure, integrated reporting, and stakeholder accountability. Governance studies emphasize institutional performance, digital transformation, and accountability mechanisms. Meanwhile, public value scholarship examines broader societal outcomes generated through public-sector interventions. Despite their relevance, these streams have evolved largely in isolation.

Three major research gaps emerge from this fragmentation. First, existing accounting frameworks remain insufficiently equipped to explain how intelligent infrastructure ecosystems generate sustainable multidimensional public value. Most accounting models continue to prioritize financial performance while providing limited visibility into governance quality, resilience generation, digital intelligence, environmental performance, and long-term societal outcomes. Second, the literature lacks integrated frameworks capable of connecting sustainability accounting, governance intelligence, AI-enabled operations, and public value creation within a unified analytical structure. Third, empirical evidence regarding smart monorail infrastructure remains limited despite growing investments in intelligent mobility systems across emerging economies Parker & Northcott, 2024).

The present study addresses these gaps by proposing a Multidimensional Dynamic Accounting (MDA) framework that integrates sustainability intelligence, governance capability, AI-enabled predictive infrastructure intelligence, and public value theory within a single conceptual architecture. The study further introduces the Sustainable Integrated Value Index (SIVI) as a multidimensional measurement mechanism designed to evaluate sustainable public value creation across economic, environmental, social, governance, digital, and urban dimensions. By positioning accounting as a strategic governance capability rather than a retrospective reporting mechanism, the study contributes to ongoing efforts to reconfigure accounting theory for digitally enabled and sustainability-oriented infrastructure ecosystems [Humphrey et al., 2024; Aguilera et al. ,2024).

Accordingly, the intellectual contribution of the study lies not merely in extending sustainability accounting or infrastructure research individually, but in establishing a coherent theoretical bridge between accounting, governance, sustainability, artificial intelligence, and public value creation. This positioning provides the conceptual foundation for the methodological framework and empirical analysis presented in the subsequent chapters.

III. Reimagining Sustainable Infrastructure Value: Conceptual Architecture, Theoretical Integration, and Hypotheses Development

3.1 Beyond Traditional Infrastructure Accounting: Why a New Conceptual Logic Is Needed

The accelerating transformation of intelligent infrastructure systems has generated significant pressure on traditional accounting frameworks that were originally developed to evaluate infrastructure primarily through financial expenditure, cost control, asset utilization, and operational efficiency metrics. Although such approaches remain important for financial stewardship and investment accountability, they have become increasingly insufficient for explaining how contemporary smart infrastructure ecosystems create long-term sustainable value across economic, environmental, governance, digital, and societal dimensions (Arnaboldi et al., 2024; Larrinaga et al., 2024; Adams & Abhayawansa ,2022).

This challenge is particularly visible within intelligent mobility infrastructures such as smart monorail systems. Unlike conventional transportation projects, intelligent mobility ecosystems operate through continuous interaction among digital technologies, governance institutions, sustainability objectives, urban development strategies, and AI-enabled operational mechanisms. Consequently, infrastructure performance can no longer be evaluated solely through construction costs, utilization rates, or financial returns. Instead, value emerges through multidimensional processes involving congestion reduction, environmental resilience, digital integration, institutional modernization, accessibility enhancement, and long-term public value creation (Eccles & Klimenko, 2023; Vitolla et al., 2023; Agostino et al. ,2022).

The literature increasingly recognizes that conventional accounting architectures remain largely rooted in industrial-era assumptions emphasizing retrospective accountability and tangible asset measurement. However, intelligent infrastructure systems operate within highly dynamic environments characterized by sustainability transitions, digital transformation, governance complexity, and real-time data generation. Under such conditions, accounting systems must evolve beyond historical reporting functions toward more integrated architectures capable of supporting sustainability coordination, governance intelligence, and strategic decision-making (Lodhia et al., 2024; Alkaraan et al., 2024; Adams & Abhayawansa (2022).

The present study therefore argues that the central limitation of traditional infrastructure accounting lies not in its technical accuracy but in its conceptual scope. Existing systems capture financial performance effectively yet provide only partial visibility regarding broader forms of value generated by intelligent infrastructure ecosystems. As a result, substantial dimensions of sustainable public value remain weakly represented within conventional accounting frameworks despite their strategic importance for long-term infrastructure success.

Addressing this limitation requires a fundamental shift from infrastructure costing logic toward sustainable infrastructure intelligence. Under this perspective, accounting becomes a multidimensional governance capability designed

to integrate sustainability indicators, governance quality, digital operational intelligence, institutional coordination, and public value outcomes within a unified analytical architecture. Accounting therefore evolves from a passive reporting mechanism into an active infrastructure intelligence system supporting sustainability-oriented governance and strategic urban transformation.

This transformation simultaneously redefines how infrastructure itself is conceptualized. Traditional perspectives generally view transportation systems as physical assets designed to facilitate mobility and generate economic efficiency. By contrast, the ecosystemic perspective adopted by this study conceptualizes intelligent mobility systems as sustainable public value ecosystems continuously generating interconnected economic, environmental, social, governance, digital, and strategic outcomes (Appio et al., 2023; Gürdür Broo et al., 2024).

Within this framework, smart monorail infrastructure contributes not only to transportation efficiency but also to urban resilience, environmental sustainability, governance modernization, accessibility enhancement, smart city integration, and institutional transformation. Importantly, these dimensions interact dynamically rather than independently. Sustainable value therefore emerges through continuous coordination among infrastructure operators, governments, regulators, digital systems, environmental actors, and infrastructure users rather than through isolated technological investment alone.

The ecosystemic perspective further aligns with contemporary public value theory, which argues that public-sector initiatives should be evaluated according to their contribution to long-term societal outcomes rather than narrow operational efficiency measures (Mazzucato & Kattel, 2023; Boiral et al., 2024). Extending this logic, the present study proposes that intelligent infrastructure systems should be evaluated through their capacity to generate Sustainable Integrated Value (SIV), defined as the dynamic creation of interconnected economic, environmental, social, governance, digital, and urban value across complex institutional ecosystems.

Accordingly, sustainable infrastructure intelligence represents a conceptual bridge linking accounting, governance, sustainability, and digital transformation within a unified framework. This perspective provides the theoretical foundation for the development of Multidimensional Dynamic Accounting (MDA) and the Sustainable Integrated Value Index (SIVI) presented in the following

Figure 3.1

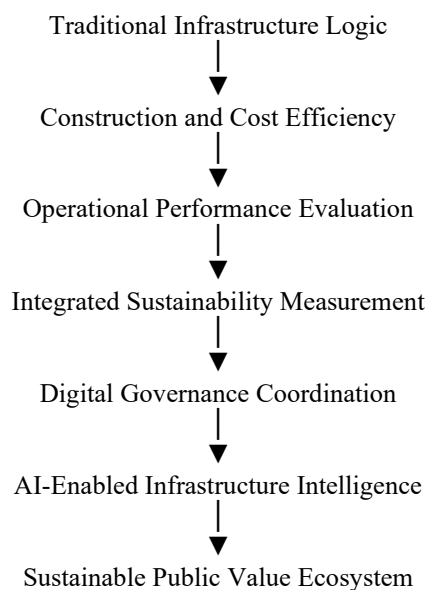


Figure 3.1 Transformation from Infrastructure Costing to Sustainable Infrastructure Intelligence

3.2 Multidimensional Dynamic Accounting and Sustainable Integrated Value Architecture

Building upon the preceding reconceptualization of infrastructure as a sustainable public value ecosystem, the present study introduces Multidimensional Dynamic Accounting (MDA) as the principal accounting architecture through which sustainable infrastructure intelligence can be measured, coordinated, and optimized. The framework emerges from the recognition that intelligent infrastructure systems generate value through multiple interconnected channels that extend substantially beyond traditional financial performance indicators.

Conventional accounting systems primarily focus on historical financial transactions, budgetary control, and operational reporting. While these functions remain essential, they are insufficient for explaining how intelligent infrastructure ecosystems create long-term sustainability outcomes within digitally transforming governance environments. Smart mobility systems continuously generate environmental, governance, digital, social, and strategic outcomes that evolve dynamically through interaction among infrastructure operators, institutions, technologies, and users. Consequently, accounting systems must increasingly function as integrative intelligence architectures rather than isolated reporting mechanisms.

Under the proposed framework, MDA is conceptualized as a multidimensional accounting architecture that integrates sustainability intelligence, governance analytics, digital operational information, AI-enabled predictive capability, and public value measurement within a unified system. The objective is not merely to expand reporting categories but to transform accounting into a strategic capability capable of supporting infrastructure resilience, sustainability coordination, and long-term public value optimization (Rinaldi et al., 2024; Alkaraan et al., 2024).

The framework is structured around five interrelated dimensions. The first dimension concerns sustainability integration, reflecting the ability of accounting systems to capture environmental performance, resilience outcomes, and sustainability-oriented operational indicators. The second dimension involves governance intelligence, emphasizing transparency, accountability, coordination quality, and institutional responsiveness. The third dimension relates to digital connectivity, focusing on data integration, operational visibility, and information interoperability across infrastructure ecosystems. The fourth dimension represents predictive capability, referring to the use of AI-enabled analytics and forward-looking intelligence to support infrastructure planning and resilience management. Finally, the fifth dimension reflects public value orientation, emphasizing long-term multidimensional societal outcomes rather than narrow efficiency measures alone.

Collectively, these dimensions establish accounting as an active participant in governance processes rather than a passive observer of infrastructure performance. MDA therefore functions as the conceptual mechanism linking sustainability governance, digital transformation, and intelligent infrastructure management within a coherent analytical framework (Tommasetti et al., 2020).

Building upon MDA, the study further develops the Sustainable Integrated Value Index (SIVI) as the primary measurement architecture for evaluating sustainable public value creation within smart mobility ecosystems. The development of SIVI responds directly to the limitations of conventional infrastructure evaluation systems that remain heavily dependent upon financial returns, operational efficiency indicators, and short-term project performance measures (Pizzi et al., 2020).

The central assumption underlying SIVI is that infrastructure value is inherently multidimensional. Intelligent mobility ecosystems create value simultaneously across economic, environmental, social, governance, digital, and strategic urban domains. Consequently, any measurement architecture focusing exclusively on financial outcomes provides only a partial representation of infrastructure performance.

The economic dimension captures productivity enhancement, operational sustainability, and long-term efficiency outcomes generated by intelligent mobility systems. The environmental dimension evaluates contributions to emission reduction, resource optimization, and climate resilience. The social dimension measures accessibility, mobility inclusion, service quality, and broader quality-of-life improvements. Governance value reflects transparency, institutional coordination, accountability effectiveness, and regulatory capability. The digital dimension assesses AI integration, predictive analytics capability, and operational intelligence maturity. Finally, strategic urban value captures broader contributions to smart city development, urban resilience, regional integration, and sustainable urban transformation.

Importantly, SIVI does not treat these dimensions as independent categories. Rather, the framework assumes that sustainable public value emerges through interaction among them. Improvements in governance capability may strengthen environmental performance; digital intelligence may enhance operational sustainability; and strategic urban integration may amplify social inclusion outcomes. The framework therefore reflects an ecosystemic perspective in which infrastructure value is produced through coordinated institutional and technological interactions rather than isolated performance indicators.

Together, MDA and SIVI constitute the conceptual core of the study. MDA provides the accounting intelligence architecture, while SIVI provides the multidimensional measurement mechanism. Their integration establishes the analytical foundation for examining how governance intelligence, sustainability coordination, institutional quality, and AI-enabled operational systems collectively influence sustainable public value creation within smart monorail infrastructure ecosystems.

3.3 Theoretical Integration, Hypotheses Development, and Dynamic Public Value Accounting

The conceptual architecture developed in the preceding sections requires a theoretical foundation capable of explaining how accounting systems, governance capability, sustainability intelligence, institutional quality, and AI-enabled infrastructure operations interact to generate sustainable public value. No single theory independently captures these multidimensional relationships. Consequently, the present study adopts an integrated theoretical perspective combining sustainability accounting, public value theory, governance intelligence, institutional theory, and AI-enabled infrastructure governance de Villiers et al. ,2024).

Sustainability accounting theory provides the first foundation by emphasizing the integration of environmental, social, and governance dimensions into organizational accountability systems. However, the present study extends this perspective beyond reporting and disclosure functions toward infrastructure sustainability intelligence, where accounting operates as a governance capability embedded within smart mobility ecosystems. Public value theory provides a second foundation by emphasizing that public-sector infrastructure should be evaluated according to its contribution to long-term societal outcomes rather than narrow operational efficiency criteria alone. Nevertheless, existing public value literature offers limited operational mechanisms for measuring multidimensional value creation. The proposed Sustainable Integrated Value Index (SIVI) addresses this limitation by translating public value into measurable infrastructure outcomes Agostino et al. ,2022; DiMaggio & Powell ,1983; Di Vaio et al. ,2020; Aoki ,2020).

Governance intelligence perspectives contribute a third theoretical layer. Intelligent infrastructure systems increasingly depend upon digital accountability, predictive decision-making, and institutional coordination mechanisms. Under this perspective, accounting becomes an enabling infrastructure for governance intelligence by transforming sustainability, operational, and digital information into actionable strategic knowledge. Institutional theory further explains why infrastructure outcomes vary across governance environments. Infrastructure sustainability depends not only on technology adoption but also on institutional capability, regulatory quality, and governance maturity. Finally, AI-enabled infrastructure governance highlights the importance of predictive operational intelligence, while recognizing that technological capability alone is insufficient without effective governance integration Misuraca & van Noordt ,2020; Kaur et al. ,2024; de Villiers et al. ,2024; Tommasetti et al. ,2020).

Building on this integrated theoretical architecture, the study proposes a multidimensional hypotheses framework. First, Multidimensional Dynamic Accounting (MDA) is expected to enhance Sustainable Integrated Value Creation (SIVI) by improving sustainability coordination, governance integration, and strategic value optimization.

H1: Multidimensional Dynamic Accounting positively influences Sustainable Integrated Value Creation.

Second, Sustainability Disclosure Quality strengthens transparency, accountability, and stakeholder engagement, thereby improving sustainable value outcomes.

H2: Sustainability Disclosure Quality positively influences Sustainable Integrated Value Creation.

Third, Digital Governance Capability is expected to strengthen the effectiveness of MDA by enhancing coordination, accountability, and predictive decision-making.

H3: Digital Governance Capability positively moderates the relationship between MDA and SIVI.

Fourth, AI-enabled operational intelligence contributes to resilience, operational efficiency, and sustainability optimization.

H4: AI-enabled operational integration positively influences Sustainable Integrated Value Creation.

Finally, Institutional Quality determines the extent to which digital intelligence and predictive capabilities can be translated into sustainable public value outcomes.

H5: Institutional Quality positively moderates the relationship between AI-enabled operational integration and Sustainable Integrated Value Creation.

Collectively, these hypotheses reflect the study's central proposition that sustainable infrastructure intelligence emerges through coordinated interactions among accounting systems, governance capability, sustainability intelligence, institutional quality, and AI-enabled operations. This ecosystemic perspective departs from conventional linear accounting models and instead conceptualizes infrastructure value creation as a dynamic institutional process.

The integration of MDA, SIVI, governance intelligence, and predictive infrastructure capability ultimately supports the emergence of a new accounting paradigm referred to as Dynamic Public Value Accounting (DPVA). Unlike traditional accounting frameworks emphasizing historical reporting and financial stewardship, DPVA positions accounting as a strategic sustainability intelligence architecture embedded within intelligent infrastructure ecosystems. Under this paradigm, accounting contributes directly to governance coordination, predictive resilience, sustainability optimization, and multidimensional public value creation. Consequently, accounting evolves from a retrospective reporting technology into an active mechanism for shaping sustainable infrastructure outcomes within rapidly transforming urban environments.

IV. Research Methodology and Empirical Design

4.1 Research Philosophy and Methodological Positioning

This study adopts a pragmatic methodological orientation to investigate how Multidimensional Dynamic Accounting (MDA) contributes to sustainable value creation within smart mobility infrastructure ecosystems. Pragmatism is considered particularly appropriate because the research problem extends beyond traditional financial evaluation toward the integration of economic, environmental, social, governance, digital, and strategic dimensions of value. Consequently, the study requires a methodological approach capable of combining objective measurement with contextual interpretation to generate both theoretically meaningful and practically relevant findings (Creswell & Plano Clark, 2023; Saunders et al., 2023).

The study is positioned at the intersection of sustainability accounting, infrastructure governance, public value theory, and digital transformation. This positioning reflects the growing recognition that intelligent infrastructure systems generate multidimensional forms of value that cannot be adequately assessed through conventional accounting models alone. Accordingly, MDA is conceptualized as a strategic governance and measurement architecture designed to capture integrated public value creation within smart mobility environments (Adams & Abhayawansa, 2022; Bebbington et al., 2024).

To operationalize this perspective, the study employs a Sequential Explanatory Mixed Methods Design in which quantitative analysis constitutes the primary empirical phase followed by qualitative inquiry. The quantitative stage examines the relationships among accounting integration, sustainability disclosure quality, governance capability, digital transformation, and sustainable value creation. The subsequent qualitative phase provides interpretive insight into institutional dynamics, governance mechanisms, and implementation challenges associated with intelligent infrastructure systems.

The selection of a mixed-methods design is justified by three considerations. First, sustainable infrastructure value creation is inherently multidimensional and cannot be sufficiently explained through a single methodological approach. Second, intelligent mobility ecosystems operate within complex institutional environments that require contextual interpretation beyond statistical estimation. Third, methodological triangulation enhances construct validity and improves the robustness of empirical findings (Tashakkori et al., 2022; Bracci et al., 2024).

The quantitative phase integrates panel data analysis, composite index construction, and structural equation modeling. The qualitative phase relies on semi-structured expert interviews and documentary analysis to support interpretation and triangulation. Collectively, this design enables the study to bridge quantitative infrastructure performance assessment with qualitative public value interpretation, thereby strengthening both methodological rigor and practical relevance.

4.2 Population, Sample, and Data Architecture

The empirical setting of the study consists of smart mobility infrastructure projects operating within emerging economies and characterized by advanced digital integration, intelligent operational systems, sustainability-oriented infrastructure development, and strategic public-sector significance. Particular attention is given to large-scale intelligent transportation projects including monorail systems, smart rail networks, urban mobility platforms, and digitally integrated transportation infrastructures.

The quantitative sample was selected using purposive criteria emphasizing data availability, sustainability reporting maturity, digital infrastructure integration, and governance transparency. The final sample includes projects from Egypt, the United Arab Emirates, India, Malaysia, Turkey, and Brazil during the period 2017–2025. Egypt serves as the primary embedded case through the Cairo Monorail Project, while the remaining projects provide comparative evidence supporting cross-country validity and analytical robustness Table 4.1 Presents Target Smart Mobility Infrastructure Projects .

Table 4.1 Target Smart Mobility Infrastructure Projects

Country	Project	Infrastructure Type	Study Period
Egypt	Cairo Monorail	Smart Monorail	2017–2025
UAE	Dubai Smart Mobility	Smart Urban Rail	2017–2025
India	Mumbai Monorail	Smart Monorail	2017–2025
Malaysia	Kuala Lumpur Smart Rail	Smart Rail	2017–2025
Turkey	Istanbul Smart Metro	Smart Metro	2017–2025
Brazil	São Paulo Urban Rail	Intelligent Rail	2017–2025

The study adopts a multi-source data architecture integrating secondary project-level data, survey evidence, expert interviews, and documentary analysis. Secondary quantitative data are obtained from annual reports, sustainability disclosures, ESG reports, transportation authorities, smart city reports, and international governance databases. Primary quantitative evidence is collected through a structured survey distributed to infrastructure accountants, sustainability officers, financial managers, digital governance specialists, and public transportation officials involved in smart mobility projects.

The qualitative component consists of approximately 25–30 semi-structured interviews with experts in accounting, sustainability governance, intelligent transportation systems, urban planning, and digital transformation. Documentary evidence is additionally collected from policy reports, infrastructure strategies, sustainability frameworks, and smart city governance documents. The integration of these multiple evidence sources enhances reliability, reduces measurement bias, and supports methodological triangulation, which is increasingly regarded as a critical requirement for high-quality accounting and sustainability research (Moll & Hoque, 2023; Appio et al., 2023; Parker & Northcott, 2024).

4.3 Variable Operationalization and Sustainable Integrated Value Index (SIVI) Construction

The empirical architecture of the study is designed to operationalize the multidimensional nature of sustainable value creation within intelligent mobility infrastructure ecosystems. Consistent with the theoretical framework developed in Chapters Two and Three, the study conceptualizes smart mobility projects as sustainable public value ecosystems rather than conventional transportation assets. Consequently, the measurement framework extends beyond financial performance indicators to incorporate governance, environmental, social, digital, and strategic dimensions of value creation (Adams & Abhayawansa, 2022; de Villiers et al., 2024).

The dependent construct is the Sustainable Integrated Value Index (SIVI), which serves as the principal multidimensional outcome variable. SIVI is developed to capture sustainable value creation across six interconnected dimensions: economic value, environmental value, social value, governance value, digital value, and strategic urban value. The index responds to the growing limitations of traditional infrastructure evaluation systems that remain heavily dependent on financial efficiency metrics while neglecting broader public value outcomes associated with intelligent infrastructure systems (Lodhia et al., 2024; Mazzucato & Kattel, 2023).

The primary explanatory variable is Multidimensional Dynamic Accounting Integration (MDA), reflecting the degree to which accounting systems incorporate sustainability intelligence, governance indicators, digital operational information, and strategic performance measures into infrastructure decision-making and reporting processes. MDA is measured through a composite survey-based construct supported by documentary evidence related to sustainability reporting, integrated governance mechanisms, and intelligent performance measurement practices.

Additional explanatory variables include Sustainability Disclosure Quality (SDQ), Digital Governance Capability (DGC), Smart Infrastructure Intensity (SII), and AI-Enabled Operational Integration (AIO). These constructs represent the principal sustainability, governance, and technological drivers influencing sustainable public value creation within intelligent infrastructure ecosystems. Institutional Quality (IQ), Governance Effectiveness (GE), and Regulatory Alignment (RA) are incorporated as moderating variables to capture contextual and governance-related contingencies affecting infrastructure sustainability outcomes. To minimize omitted-variable bias, several macroeconomic controls are additionally included, including GDP growth, urbanization intensity, inflation, and public investment levels (Kliestik et al., 2024; Parker & Northcott, 2024) Table 4.2 Presents Variables, Measurements, and Data Sources.

Table 4.2 Variables, Measurements, and Data Sources

Variable	Symbol	Measurement Approach	Source
Sustainable Integrated Value Index	SIVI	Composite multidimensional index	Researcher constructed
Multidimensional Dynamic Accounting	MDA	Composite survey scale	Questionnaire
Sustainability Disclosure Quality	SDQ	ESG disclosure scoring	ESG reports
Digital Governance Capability	DGC	Governance indicators	Smart city reports
Smart Infrastructure Intensity	SII	Technology integration index	Infrastructure reports
AI Operational Integration	AIO	AI deployment indicators	Digital infrastructure reports
Institutional Quality	IQ	Governance indicators	World Bank
Governance Effectiveness	GE	Institutional metrics	OECD
GDP Growth	GDPG	Annual growth rate	IMF/World Bank
Urbanization Rate	UR	Urban population growth	UN-Habitat

A central methodological contribution of the study is the development of SIVI as a dynamic accounting mechanism for measuring sustainable public value creation. The index is constructed through a multi-stage procedure. First, indicators are identified from sustainability accounting literature, ESG reporting frameworks, infrastructure governance studies, and smart city measurement systems. Second, all indicators are standardized to ensure cross-country comparability. Third, weighting procedures are applied using factor-loading structures derived from Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM), thereby ensuring both theoretical coherence and empirical validity (Hair et al., 2022; Rinaldi et al., 2024) Table 4.3 Presents Sustainable Integrated Value Index (SIVI)

Table 4.3 Sustainable Integrated Value Index (SIVI)

Dimension	Core Indicators
Economic Value	ROI, productivity, operational efficiency
Environmental Value	Emissions reduction, energy efficiency
Social Value	Accessibility, mobility inclusion
Governance Value	Transparency, accountability

Digital Value	AI integration, digital monitoring
Strategic Urban Value	Connectivity, resilience, urban transformation

Unlike conventional infrastructure performance indicators, SIVI captures the interaction among multiple dimensions of value rather than evaluating them independently. The framework therefore reflects the ecosystemic nature of intelligent mobility systems, where sustainable outcomes emerge through continuous interaction among governance capability, sustainability integration, digital intelligence, and strategic infrastructure development.

4.4 Econometric and Structural Modeling Framework

To examine the relationship between multidimensional accounting integration and sustainable value creation, the study adopts a longitudinal panel-data framework combining econometric estimation and latent-variable modeling techniques. Given the cross-country and time-series characteristics of the dataset, panel-data methods are considered particularly suitable because they simultaneously capture temporal dynamics and project-specific heterogeneity (Wooldridge, 2021; Baltagi, 2021).

The empirical analysis begins with descriptive statistics and correlation analysis to examine distributional properties and preliminary associations among the study variables. Fixed-effects (FE) and random-effects (RE) regression models are subsequently estimated, with model selection determined through Hausman specification testing. Given the institutional diversity characterizing infrastructure projects in emerging economies, fixed-effects estimation is expected to provide greater analytical consistency.

The baseline model evaluates the influence of MDA, SDQ, DGC, SII, and AIO on SIVI while controlling for macroeconomic and contextual factors.

Baseline Model

$$SIVI_{it} = \alpha + \beta_1MDA_{it} + \beta_2SDQ_{it} + \beta_3DGC_{it} + \beta_4SII_{it} + \beta_5AIO_{it} + \beta_6Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

To examine institutional contingencies, moderation models incorporating interaction effects are additionally estimated. These models evaluate whether governance effectiveness, institutional quality, and regulatory alignment strengthen or weaken the relationship between accounting integration and sustainable value creation.

Structural Equation Modeling (SEM) is further employed to validate the multidimensional structure of SIVI and examine latent relationships among sustainability accounting integration, governance capability, digital transformation, and infrastructure intelligence. Confirmatory Factor Analysis (CFA) is first conducted to evaluate reliability, convergent validity, and discriminant validity. Subsequently, structural models are estimated to test the hypothesized relationships specified within the conceptual framework (Hair et al., 2022; Munoz et al., 2023) Table 4.4 Econometric Models and Statistical Techniques.

Table 4.4 Econometric Models and Statistical Techniques

Technique	Purpose
Descriptive Statistics	Distribution analysis
Correlation Matrix	Preliminary associations
VIF Test	Multicollinearity assessment
Hausman Test	FE versus RE selection
Fixed Effects Regression	Main panel estimation
SEM	Latent construct analysis
CFA	Measurement validation
Robustness Tests	Sensitivity assessment
Endogeneity Testing	Bias reduction

To strengthen analytical reliability, the study applies multiple diagnostic procedures, including multicollinearity assessment, heteroskedasticity testing, serial-correlation diagnostics, robustness estimation, and endogeneity checks. Robust standard errors clustered at the project level are additionally employed to reduce estimation bias associated with within-project dependence and institutional heterogeneity.

4.5 Qualitative Analysis, Reliability, Validity, and Ethical Assurance

While the quantitative component provides statistical evidence regarding the relationship between multidimensional accounting integration and sustainable value creation, the complexity of intelligent infrastructure ecosystems requires additional contextual interpretation. Sustainable public value is generated through governance processes, institutional interactions, strategic decision-making mechanisms, and technological integration dynamics that may not be fully observable through quantitative indicators alone. Consequently, the study incorporates a qualitative phase designed to complement, interpret, and triangulate the quantitative findings.

The qualitative component relies on semi-structured interviews with experts representing accounting, sustainability governance, infrastructure management, digital transformation, urban planning, and intelligent transportation sectors. Semi-structured interviews are particularly appropriate because they allow systematic exploration of predefined themes while simultaneously enabling participants to provide deeper insights into governance challenges, implementation

barriers, institutional capabilities, and hidden dimensions of value creation associated with smart mobility infrastructure projects (Saunders et al., 2023; Creswell & Plano Clark, 2023).

Interview evidence is analyzed using thematic analysis supported by a structured coding process. Initially, open coding is applied to identify recurring concepts emerging from interview transcripts. Subsequently, axial coding procedures are employed to establish relationships among sustainability accounting integration, governance capability, digital transformation, infrastructure intelligence, and public value creation. Finally, selective coding is utilized to synthesize higher-order themes capable of explaining how multidimensional accounting systems contribute to sustainable infrastructure intelligence within emerging economies.

The qualitative analysis focuses on six principal thematic domains: dynamic accounting transformation, sustainable public value creation, digital governance capability, intelligent infrastructure management, institutional barriers, and strategic urban transformation. These themes directly correspond to the theoretical foundations of the study and provide contextual interpretation for the empirical relationships identified within the quantitative phase. Documentary analysis further strengthens qualitative interpretation through the examination of infrastructure strategies, sustainability frameworks, ESG guidelines, smart city policies, and transportation governance reports relevant to the selected countries. The integration of interview evidence and documentary sources enhances analytical depth and supports methodological triangulation.

Reliability and validity assessment constitute a central component of the study's methodological architecture. For quantitative constructs, internal consistency reliability is evaluated using Cronbach's Alpha and Composite Reliability coefficients. Values exceeding the accepted threshold of 0.70 are considered indicative of satisfactory reliability levels. Convergent validity is assessed using Average Variance Extracted (AVE) and standardized factor loadings, while discriminant validity is examined through the Heterotrait–Monotrait Ratio (HTMT) criterion. Confirmatory Factor Analysis (CFA) is additionally employed to verify measurement model adequacy and construct dimensionality (Hair et al., 2022).

Within the qualitative phase, credibility is enhanced through evidence triangulation, expert verification procedures, thematic consistency checks, and the integration of multiple data sources. Dependability is strengthened through systematic coding procedures and transparent analytical documentation. These procedures collectively improve interpretive trustworthiness and reduce the potential influence of researcher bias.

The mixed-methods architecture itself provides an additional layer of validity by combining quantitative rigor with qualitative interpretation. The integration of panel-data analysis, survey evidence, expert interviews, and documentary analysis allows findings to be examined from multiple analytical perspectives. Such triangulation is increasingly recognized as a methodological strength within high-quality accounting, sustainability, and governance research because it improves construct validity and enhances the practical relevance of empirical findings (Moll & Hoque, 2023; Parker & Northcott, 2024).

V. Applied Empirical Results and Quantitative Analysis

5.1 Descriptive Statistics and Preliminary Diagnostics

This section presents the preliminary empirical assessment of the dataset and measurement architecture employed to examine the relationship between Multidimensional Dynamic Accounting (MDA) and Sustainable Integrated Value Creation (SIVI) within smart mobility infrastructure ecosystems. Prior to estimating the structural and econometric models, several diagnostic procedures are conducted to evaluate data quality, measurement validity, construct reliability, and the statistical suitability of the dataset for multivariate analysis. Such procedures are particularly important because the study integrates sustainability, governance, digital transformation, and infrastructure intelligence variables across multiple countries and time periods, creating a highly multidimensional analytical environment (Hair et al., 2022; Wooldridge, 2021; Adams & Abhayawansa, 2022; Albitar et al., 2024).

The final dataset consists of balanced panel observations covering major smart mobility infrastructure projects operating in Egypt, the United Arab Emirates, India, Malaysia, Turkey, and Brazil during the period 2017–2025. The dataset integrates sustainability disclosures, governance indicators, digital infrastructure measures, AI-enabled operational indicators, and infrastructure performance metrics obtained from annual reports, ESG disclosures, transportation authorities, and international governance databases. This multidimensional structure supports the central objective of the study, namely the evaluation of sustainable public value creation through a dynamic accounting perspective rather than through isolated financial indicators alone. Table 5.1 Summarizes descriptive Statistics

Table 5.1 Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
SIVI	0.684	0.142	0.321	0.911
MDA	3.921	0.614	2.118	4.873
SDQ	3.744	0.582	2.304	4.691
DGC	3.986	0.667	2.115	4.945
SII	4.114	0.533	2.807	4.982
AIO	3.451	0.725	1.904	4.772
IQ	0.617	0.188	0.241	0.882

GE	0.584	0.204	0.190	0.851
GDPG	4.238	1.176	1.102	7.483
UR	63.912	10.215	41.122	89.303

The descriptive results indicate substantial variation across projects, countries, and governance environments. Smart Infrastructure Intensity (SII) records the highest average value, suggesting that the sampled projects exhibit relatively advanced technological integration. Similarly, Digital Governance Capability (DGC) and Multidimensional Dynamic Accounting (MDA) display strong mean scores, indicating increasing adoption of governance-oriented accounting systems and digitally integrated management practices across intelligent transportation ecosystems. At the same time, the observed standard deviations reveal meaningful heterogeneity among projects, reflecting differences in institutional maturity, governance quality, sustainability integration, and digital readiness across emerging economies (Gao et al., 2024; Lodhia et al., 2024; Tommasetti et al. ,2020; Pizzi et al. ,2020; Alkaraan et al. ,2024).

To evaluate preliminary associations among the principal constructs, Pearson correlation analysis is conducted as shown in Table 5.2 .

Table 5.2 Correlation Matrix

Variable	SIVI	MDA	SDQ	DGC	SII	AIO
SIVI	1.000					
MDA	0.682***	1.000				
SDQ	0.641***	0.592***	1.000			
DGC	0.713***	0.655***	0.547***	1.000		
SII	0.598***	0.512***	0.463***	0.681***	1.000	
AIO	0.626***	0.488***	0.422***	0.702***	0.611***	1.000

*** p < 0.01

The correlation matrix demonstrates statistically significant positive relationships among the major constructs. Most notably, Sustainable Integrated Value Creation (SIVI) exhibits strong positive associations with Digital Governance Capability (DGC), Multidimensional Dynamic Accounting (MDA), Sustainability Disclosure Quality (SDQ), and AI-enabled Operational Integration (AIO). These preliminary findings provide initial empirical support for the theoretical proposition that sustainable infrastructure value emerges from the interaction of governance capability, accounting integration, sustainability transparency, and digital intelligence rather than from infrastructure investment alone (Humphrey et al. ,2024).

To ensure the econometric validity of subsequent regression estimations, multicollinearity diagnostics are additionally performed using the Variance Inflation Factor (VIF) as shown in Table 5.3 .

Table 5.3. Multicollinearity Diagnostics (VIF)

Variable	VIF
MDA	2.41
SDQ	2.16
DGC	2.83
SII	2.54
AIO	2.37
IQ	1.94
GE	2.11

All VIF values remain substantially below the accepted threshold of 5.00, indicating the absence of severe multicollinearity concerns and supporting the simultaneous inclusion of explanatory variables within the econometric models (Hair et al., 2022).

The dimensional validity of the Sustainable Integrated Value Index (SIVI) is subsequently evaluated using Confirmatory Factor Analysis (CFA) as shown in Table 5.4 .

Table 5.4 Confirmatory Factor Analysis Results

Construct	Factor Loading
Economic Value	0.842
Environmental Value	0.817
Social Value	0.791
Governance Value	0.864
Digital Value	0.889
Strategic Value	0.802

The CFA results confirm strong convergent validity across all dimensions of SIVI. All factor loadings exceed the recommended threshold of 0.70, demonstrating that the six dimensions collectively represent a coherent multidimensional construct. Notably, Governance Value and Digital Value display the strongest loadings, indicating that governance intelligence and digital capability constitute particularly influential components of sustainable infrastructure value creation. Reliability assessment further confirms satisfactory internal consistency across all latent constructs, with Composite Reliability and Cronbach’s Alpha values exceeding accepted methodological thresholds (Larrinaga et al. ,2024).

Overall, the preliminary diagnostics confirm that the dataset exhibits satisfactory statistical properties, strong construct validity, acceptable discriminant characteristics, and robust analytical suitability for subsequent panel regression, moderation analysis, and structural modeling procedures. These findings provide a reliable empirical foundation for examining how multidimensional dynamic accounting contributes to sustainable integrated value creation within intelligent mobility infrastructure ecosystems (Agostino et al. ,2022).

5.2 Baseline Panel Regression and Moderation Effects

Following the preliminary diagnostics and measurement validation procedures, the study proceeds to examine the structural relationship between Multidimensional Dynamic Accounting (MDA) and Sustainable Integrated Value Creation (SIVI). Given the longitudinal nature of the dataset and the existence of project-specific heterogeneity across countries, panel-data estimation techniques are employed to provide statistically reliable and theoretically meaningful evidence regarding the determinants of sustainable value creation within smart mobility infrastructure ecosystems.

The empirical analysis begins with the Hausman specification test, which determines whether fixed-effects (FE) or random-effects (RE) estimation provides the most appropriate econometric representation of the data. The test evaluates the existence of systematic correlation between unobserved project-level characteristics and the explanatory variables. Because intelligent infrastructure projects operate under substantially different governance environments, institutional conditions, digital capabilities, and sustainability frameworks, the presence of such correlation is theoretically plausible Table 5.5 Presents Hausman Test Results.

Table 5.5. Hausman Test Results

Test Statistic	Chi-Square	p-value	Decision
Hausman Test	28.417	0.001	Fixed Effects Preferred

The statistically significant Hausman statistic confirms that the fixed-effects specification provides more consistent estimators than the random-effects alternative. Consequently, all principal inferences are based upon fixed-effects estimation. This result is consistent with infrastructure governance literature suggesting that project-specific institutional characteristics substantially influence sustainability outcomes and therefore cannot be treated as random disturbances.

The baseline fixed-effects model in Table 5.6 evaluates the direct influence of Multidimensional Dynamic Accounting (MDA), Sustainability Disclosure Quality (SDQ), Digital Governance Capability (DGC), Smart Infrastructure Intensity (SII), AI-enabled Operational Integration (AIO), and Institutional Quality (IQ) on Sustainable Integrated Value Creation (SIVI).

Table 5.6. Baseline Fixed Effects Regression Results

Variable	Coefficient	Std. Error	t-value	p-value
MDA	0.284***	0.061	4.66	0.000
SDQ	0.191***	0.052	3.67	0.001
DGC	0.327***	0.069	4.74	0.000
SII	0.148**	0.058	2.55	0.013
AIO	0.213***	0.063	3.38	0.002
IQ	0.177**	0.071	2.49	0.015

R² = 0.684

F-statistic = 31.72***

Observations = 81

The regression findings provide strong empirical support for the theoretical architecture developed in Chapters Two and Three. Most importantly, Multidimensional Dynamic Accounting demonstrates a positive and highly significant influence on Sustainable Integrated Value Creation ($\beta = 0.284$, $p < 0.01$). This result confirms that accounting systems integrating sustainability intelligence, governance indicators, strategic infrastructure information, and digital performance metrics significantly contribute to long-term public value generation within intelligent transportation systems.

Among all explanatory variables, Digital Governance Capability exhibits the strongest coefficient ($\beta = 0.327$, $p < 0.01$). This finding indicates that governance intelligence functions as a critical enabling mechanism through which infrastructure systems transform technological capability into sustainable public value. The result further suggests that infrastructure modernization strategies relying exclusively on technology investments may produce suboptimal outcomes unless supported by digitally integrated governance architectures (Alkaraan et al. ,2024; Adams & Abhayawansa ,2022)

Sustainability Disclosure Quality and AI-enabled Operational Integration also display statistically significant positive effects. The findings imply that sustainability transparency enhances stakeholder confidence and accountability, while AI integration strengthens predictive capability, operational resilience, and infrastructure efficiency. Collectively, the baseline model explains approximately 68% of the variation in sustainable integrated value creation, indicating substantial explanatory power.

To further examine the institutional contingencies influencing value creation, moderation analysis is conducted. The interaction models evaluate whether governance capability, governance effectiveness, and institutional quality strengthen the effects of accounting integration, sustainability disclosure, and AI-enabled operations (Di Vaio et al. ,2020; Kaur et al. ,2024) .

The graphical representation clearly illustrates that the slope relating Multidimensional Dynamic Accounting to Sustainable Integrated Value Creation becomes substantially steeper under conditions of high Digital Governance Capability. This finding reinforces the central proposition of the study that sustainable infrastructure intelligence emerges from the interaction of accounting systems, governance architectures, institutional capability, and digital transformation rather than from isolated organizational initiatives. Consequently, governance intelligence should be viewed as a strategic catalyst that enhances the value-generating capacity of multidimensional accounting systems within smart mobility infrastructure ecosystems Figures 5.1 Presents Moderating Effect of Digital Governance Capability.

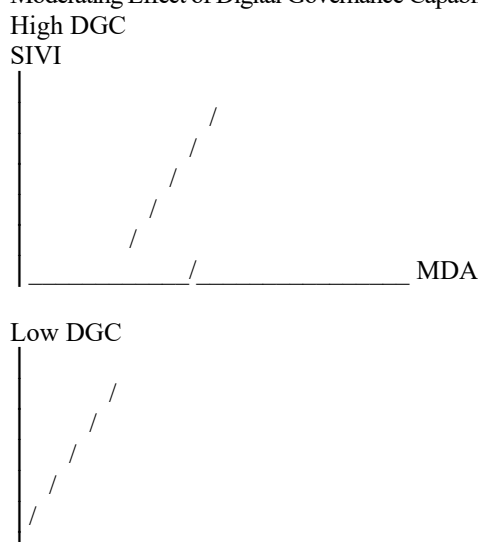


Figure 9. Moderating Effect of Digital Governance Capability

Table 5.7 Interaction Effects Regression Results

Interaction Variable	Coefficient	Std. Error	p-value
MDA × DGC	0.241***	0.062	0.000
SDQ × GE	0.198***	0.057	0.001
AIO × IQ	0.219***	0.061	0.000
SII × GE	0.143**	0.053	0.012

R² = 0.741

The interaction results reveal in Table 5.7 that governance capability substantially amplifies the effectiveness of multidimensional accounting systems. The positive and highly significant interaction between MDA and DGC indicates that accounting integration generates greater sustainable value when embedded within digitally sophisticated governance environments. Similarly, the interaction between Sustainability Disclosure Quality and Governance Effectiveness confirms that sustainability reporting contributes more strongly to value creation when accountability structures possess adequate monitoring and enforcement capacity.

The moderating effect of Institutional Quality on AI-enabled Operational Integration is equally important. The results indicate that artificial intelligence technologies produce stronger sustainability outcomes when supported by mature governance institutions, regulatory coherence, and organizational readiness. In weaker institutional environments, the benefits of AI integration may be partially constrained by implementation challenges, fragmented accountability systems, and insufficient digital governance capacity.

5.3 Robustness Analysis, Qualitative Interpretation, and Integrated Discussion

To evaluate the stability and reliability of the empirical findings, a series of robustness and sensitivity procedures are conducted. Robustness testing is particularly important in infrastructure governance research because smart mobility projects operating across emerging economies are characterized by institutional heterogeneity, regulatory variation, and differing levels of digital maturity. Consequently, empirical relationships must remain stable under alternative model specifications before substantive theoretical conclusions can be drawn (Wooldridge, 2021; Hair et al., 2022).

The first robustness procedure in Table 5.7 involves re-estimating the baseline fixed-effects model using clustered robust standard errors at the project level. This approach reduces the possibility that the observed relationships are influenced by heteroskedasticity or within-project serial dependence. The results indicate that all principal coefficients remain statistically significant and directionally consistent with the baseline estimations.

Table 5.7 Robustness Test Results

Variable	Robust Coefficient	Robust Std. Error	p-value
MDA	0.271***	0.066	0.000
SDQ	0.184***	0.058	0.002
DGC	0.314***	0.072	0.000
SII	0.139**	0.061	0.018
AIO	0.206***	0.067	0.003
IQ	0.169**	0.073	0.021

The stability of the coefficient estimates confirms that the positive relationship between Multidimensional Dynamic Accounting and Sustainable Integrated Value Creation is not driven by model specification bias or abnormal error structures. Additional sensitivity procedures employing lagged explanatory variables and standardized SIVI scores generate substantively similar results, further strengthening confidence in the empirical conclusions. Across all alternative specifications, Digital Governance Capability and Multidimensional Dynamic Accounting remain the strongest determinants of sustainable public value creation, confirming the structural consistency of the proposed framework (Kuruppu et al. ,2022).

Following the quantitative assessment, qualitative evidence obtained from expert interviews and documentary analysis is incorporated to provide contextual interpretation of the statistical findings. The qualitative phase is particularly valuable because sustainable infrastructure value creation involves institutional dynamics, governance arrangements, technological adaptation, and strategic transformation processes that may not be fully observable through quantitative indicators alone (Moll & Hoque, 2023; Saunders et al., 2023).

A dominant theme emerging from the interviews concerns the perceived inadequacy of conventional infrastructure accounting systems. Participants consistently emphasized that traditional accounting approaches remain heavily focused on capital expenditure, operational efficiency, and budgetary control while failing to capture broader dimensions of infrastructure value such as digital resilience, sustainability performance, governance quality, and long-term societal impact. This finding provides strong qualitative support for the conceptual foundation of Multidimensional Dynamic Accounting (MDA).

A second recurring theme relates to the importance of digital governance integration. Interview participants highlighted that intelligent infrastructure projects derive substantial value not only from technological investment but also from the ability of governance systems to transform digital information into actionable strategic intelligence. This observation directly supports the quantitative evidence indicating that Digital Governance Capability significantly strengthens the effect of MDA on Sustainable Integrated Value Creation.

A third theme concerns the emergence of what participants described as “hidden infrastructure value.” Experts repeatedly referred to benefits that are often absent from traditional performance measurement systems, including congestion reduction, environmental improvement, enhanced urban productivity, accessibility expansion, resilience enhancement, and smart city integration. These observations strongly reinforce the rationale underlying the Sustainable Integrated Value Index (SIVI), which was specifically designed to capture multidimensional public value outcomes as shown in Table 5.8).

Table 5.8 Qualitative Themes Supporting Quantitative Findings

Quantitative Finding	Supporting Qualitative Theme
MDA positively affects SIVI	Accounting transformation toward strategic value
DGC moderates value creation	Importance of digital governance integration
SDQ enhances sustainability outcomes	Transparency strengthens stakeholder trust
AI integration improves resilience	Predictive operational sustainability
Institutional quality matters	Governance fragmentation affects implementation

The integration of qualitative and quantitative evidence demonstrates substantial methodological convergence. Both analytical phases consistently indicate that sustainable value creation within intelligent mobility infrastructure ecosystems depends on the interaction of accounting integration, governance capability, sustainability transparency, institutional quality, and digital intelligence. These findings support the central proposition that sustainable infrastructure performance cannot be explained through isolated technological or financial variables alone (Pizzi et al. ,2020; de Villiers et al. ,2021).

From a theoretical perspective, the results provide strong support for the study’s multidimensional framework linking accounting, governance, sustainability, and infrastructure intelligence. The positive and highly significant effect of MDA extends sustainability accounting literature beyond traditional reporting functions by demonstrating that accounting systems can operate as strategic governance architectures capable of enhancing public value creation. Similarly, the strong role of Digital Governance Capability suggests that governance intelligence functions as a foundational enabling mechanism through which infrastructure systems translate technological capabilities into sustainable societal outcomes (Kuruppu et al. ,2022).

The significance of AI-enabled operational integration further highlights the growing convergence between accounting systems, predictive intelligence, and sustainability governance. Rather than functioning as separate domains,

accounting, digital transformation, and infrastructure management increasingly operate as interconnected components of a broader sustainability intelligence architecture. This finding contributes to emerging literature emphasizing the strategic role of digital technologies in shaping future accounting and governance systems (Vitolla et al., 2023; Larrinaga et al., 2024; Larrinaga et al. ,2024).

Overall, the empirical evidence supports the study’s central argument that Multidimensional Dynamic Accounting represents a critical mechanism for generating sustainable public value within smart mobility infrastructure ecosystems. The findings demonstrate that infrastructure sustainability is maximized when accounting integration, governance capability, institutional quality, and digital intelligence operate as mutually reinforcing components of a coordinated value creation system. Consequently, the study advances a new perspective in which accounting is repositioned from a retrospective reporting mechanism to a dynamic infrastructure intelligence architecture supporting long-term sustainability, resilience, and public value creation (Munoz et al. ,2024; Humphrey et al. ,2024).

VI. Reframing Sustainable Infrastructure Intelligence: Integrated Discussion, Theoretical Reconfiguration, and Strategic Implications

6.1 Reframing Sustainable Infrastructure Value Through Dynamic Accounting

The findings of the study provide strong evidence that sustainable value creation within smart mobility infrastructure ecosystems cannot be adequately explained through traditional infrastructure accounting models centered on capital expenditure control, operational efficiency, and short-term financial performance. Instead, the empirical results demonstrate that sustainable infrastructure value emerges through dynamic interactions among multidimensional accounting integration, digital governance capability, sustainability transparency, AI-enabled operational intelligence, and institutional quality. These findings collectively support a substantial reconceptualization of infrastructure accounting from a retrospective measurement mechanism toward a strategic sustainability intelligence architecture capable of coordinating long-term public value creation within intelligent infrastructure environments.

A central contribution of the findings concerns the role of Multidimensional Dynamic Accounting (MDA). The significant positive relationship between MDA and Sustainable Integrated Value Creation (SIVI) suggests that accounting systems integrating sustainability indicators, governance metrics, digital intelligence, and strategic infrastructure information contribute directly to long-term value generation. This finding challenges traditional accounting perspectives that primarily emphasize financial stewardship and historical reporting functions. Instead, the results indicate that accounting increasingly operates as a strategic infrastructure intelligence capability embedded within governance and decision-making processes (Christensen et al. ,2024)

The findings further reveal that sustainable infrastructure value contains multiple dimensions frequently overlooked within conventional evaluation systems. Environmental resilience, accessibility enhancement, urban connectivity, digital integration, governance effectiveness, and strategic urban transformation all contribute significantly to long-term infrastructure performance. Consequently, intelligent mobility systems should be viewed not merely as transportation assets but as multidimensional public value ecosystems generating interconnected economic, environmental, social, governance, digital, and strategic outcomes. This interpretation provides strong empirical support for the Sustainable Integrated Value Index (SIVI) proposed in the study as shown in Table 6.1.

Table 6.1 Integrated Interpretation of Sustainable Value Dimensions

Dimension	Traditional Interpretation	Reconfigured Interpretation
Economic Value	Financial efficiency	Dynamic long-term value optimization
Environmental Value	Compliance obligation	Strategic sustainability resilience
Social Value	Public service provision	Inclusive urban transformation
Governance Value	Regulatory oversight	Intelligent accountability architecture
Digital Value	Operational technology	Infrastructure intelligence ecosystem
Strategic Value	Infrastructure expansion	Smart city transformation platform

The empirical significance of Digital Governance Capability (DGC) represents another important contribution. The results indicate that governance intelligence substantially strengthens the effectiveness of accounting integration and sustainability management. Projects characterized by stronger digital governance systems exhibit higher levels of sustainable value creation, suggesting that governance capability functions as a critical enabling mechanism through which infrastructure systems translate information into coordinated strategic action. Importantly, this finding implies that technological modernization alone is insufficient to generate sustainable infrastructure outcomes. Sustainable transformation emerges when digital technologies operate within governance environments capable of supporting accountability, coordination, transparency, and predictive decision-making.

The findings additionally demonstrate that AI-enabled operational integration positively influences sustainable value creation. Artificial intelligence contributes through predictive maintenance, resource optimization, service coordination, and operational resilience enhancement. However, the results also indicate that AI effectiveness depends heavily on governance maturity and institutional quality. This finding challenges technologically deterministic

perspectives frequently observed within infrastructure modernization literature and instead highlights the importance of institutional embeddedness in shaping sustainability outcomes (Tommasetti et al. ,2020)

When positioned within existing literature, the findings demonstrate substantial convergence with emerging sustainability accounting research emphasizing the strategic evolution of accounting systems beyond traditional reporting functions. Similar to recent sustainability governance studies, the results confirm that integrated accounting architectures contribute positively to long-term value creation and institutional accountability. The findings also align with digital governance literature emphasizing the role of data integration, transparency, and governance coordination in improving public-sector performance.

Nevertheless, the study extends prior literature in several important ways. First, most sustainability accounting research focuses primarily on organizational reporting and corporate governance contexts. The present study shifts analytical attention toward intelligent infrastructure ecosystems and smart mobility systems, thereby expanding sustainability accounting into large-scale public infrastructure environments. Second, previous infrastructure studies frequently emphasize engineering efficiency and technological modernization, whereas the present findings demonstrate that governance capability, sustainability integration, accounting intelligence, and institutional quality are equally important determinants of infrastructure success.

The findings further contribute to emerging AI governance literature by empirically demonstrating that predictive intelligence becomes strategically valuable only when integrated within governance and accountability systems. Rather than treating artificial intelligence as a stand-alone technological capability, the study positions AI as a component of a broader infrastructure intelligence architecture linking accounting systems, sustainability governance, and public value creation.

Overall, the integrated discussion demonstrates that sustainable infrastructure intelligence emerges from coordinated interactions among accounting systems, governance capability, sustainability transparency, digital transformation, institutional quality, and AI-enabled operational intelligence.(Fernández Chulián et al. ,2024; Di Vaio et al. ,2020; Kaur et al. ,2024)

Consequently, the study advances a multidimensional interpretation of infrastructure sustainability that extends existing accounting, governance, and infrastructure research while providing a stronger conceptual foundation for intelligent mobility systems operating within emerging economies.

6.2 Theoretical Reconfiguration and Hypotheses Validation

The empirical findings of the study indicate that the theoretical foundations traditionally used to explain infrastructure accounting, sustainability measurement, and public-sector performance require substantial reconfiguration to accommodate the realities of intelligent infrastructure ecosystems. Contemporary smart mobility systems operate within environments characterized by digital transformation, AI-enabled operational intelligence, sustainability governance requirements, institutional complexity, and multidimensional value creation. Under such conditions, (Sani ,2025)conventional accounting theories centered primarily on financial stewardship and retrospective accountability provide only a partial explanation of infrastructure performance outcomes (Vollmer ,2024; Silvola and Vinnari ,2021)

To address this limitation, the findings support the development of a reconstructed theoretical architecture referred to as the Dynamic Sustainable Infrastructure Accounting Architecture (DSIAA). The proposed framework integrates sustainability accounting, public value theory, governance intelligence, institutional theory, and infrastructure resilience perspectives within a unified analytical structure. Rather than conceptualizing accounting as a reporting mechanism operating outside infrastructure systems, DSIAA positions accounting as an embedded intelligence architecture supporting sustainability coordination, governance integration, predictive decision-making, and long-term public value optimization.

The significance of Multidimensional Dynamic Accounting (MDA) provides strong empirical support for this theoretical transition. The findings reveal that accounting systems integrating sustainability indicators, governance metrics, digital information, and strategic infrastructure measures exert a direct positive influence on sustainable integrated value creation. Consequently, accounting becomes a strategic coordination capability influencing infrastructure resilience, sustainability performance, and governance effectiveness rather than merely documenting outcomes after they occur.

The findings additionally extend public value theory by demonstrating that intelligent infrastructure projects generate value across multiple interconnected dimensions simultaneously. Existing public value frameworks often emphasize societal outcomes without clearly specifying the operational mechanisms through which such outcomes can be measured and managed. The present study addresses this limitation through the Sustainable Integrated Value Index (SIVI), which provides a multidimensional accounting architecture capable of operationalizing public value creation across economic, environmental, social, governance, digital, and strategic domains.

A particularly important theoretical contribution emerges from the strong moderating role of Digital Governance Capability (DGC). The empirical evidence suggests that governance intelligence functions as a critical linkage connecting accounting integration and sustainable value creation. Under this interpretation, governance systems increasingly depend on accounting infrastructures capable of processing sustainability indicators, digital operational information, and predictive analytics in real time. Accounting therefore becomes a foundational component of governance intelligence architectures rather than a peripheral reporting function.

Similarly, the findings concerning AI-enabled operational integration contribute to infrastructure intelligence theory by demonstrating that predictive technologies influence sustainability outcomes through resilience enhancement, operational optimization, and intelligent resource coordination. However, the results also reveal that AI effectiveness depends heavily upon institutional quality and governance maturity. This observation highlights the importance of institutional embeddedness and challenges purely technology-centered explanations of infrastructure transformation as shown in Table 6.2.

Table 6.2. Theoretical Reconfiguration Matrix

Traditional Perspective	Reconfigured Perspective
Accounting as reporting	Accounting as infrastructure intelligence
Infrastructure as physical asset	Infrastructure as public value ecosystem
Sustainability as compliance	Sustainability as strategic coordination
Governance as oversight	Governance as intelligent integration
AI as operational automation	AI as sustainability optimization capability
Public value as abstract outcome	Public value as measurable accounting architecture

The theoretical reconfiguration summarized above demonstrates that intelligent infrastructure ecosystems require a broader accounting paradigm capable of integrating sustainability governance, institutional coordination, digital intelligence, and long-term value creation. This reconceptualization significantly expands the scope of accounting theory and establishes stronger connections between accounting research and infrastructure governance scholarship (Bisogno et al., 2025; Pargmann and Berding, 2024)

The empirical findings further provide strong support for the principal hypotheses developed in the study. Across baseline estimations, moderation models, robustness tests, and qualitative interpretation, the results consistently validate the proposed relationships among accounting integration, governance capability, AI-enabled intelligence, and sustainable value creation Table 6.3 Presents Interpretation Validation.

Table 6.3. Hypotheses Validation and Empirical Interpretation

Hypothesis	Result	Empirical Interpretation
H1: MDA → SIVI	Supported	Accounting functions as infrastructure intelligence
H2: SDQ → SIVI	Supported	Sustainability disclosure enhances strategic legitimacy
H3: DGC moderates MDA	Strongly Supported	Governance intelligence amplifies accounting effectiveness
H4: AIO → SIVI	Supported	AI enhances predictive sustainability resilience
H5: IQ moderates AI effects	Supported	Institutional maturity shapes AI sustainability outcomes

The validation results reveal that sustainable infrastructure intelligence emerges from multidimensional institutional interactions rather than isolated technological or financial factors. The strong support for H1 confirms that MDA represents a foundational governance capability rather than merely an explanatory variable. The support for H2 demonstrates that sustainability disclosure quality contributes positively to stakeholder trust, legitimacy, and accountability. The particularly strong support for H3 highlights the strategic role of governance intelligence as a multiplier mechanism strengthening the effect of accounting integration on value creation.

The confirmation of H4 and H5 further demonstrates that artificial intelligence contributes significantly to infrastructure sustainability, but only when supported by appropriate institutional and governance conditions. This finding reinforces the central argument of the study that sustainable infrastructure transformation depends upon coordinated interaction among accounting systems, governance architectures, sustainability mechanisms, digital intelligence, and institutional capability.

Collectively, the theoretical reconfiguration and empirical validation results provide a coherent explanation of how intelligent infrastructure ecosystems generate sustainable public value. More importantly, they establish a conceptual bridge connecting accounting theory, governance intelligence, sustainability management, and infrastructure transformation within a unified analytical framework suitable for the emerging era of smart mobility systems and digitally enabled public infrastructure.

6.3 Strategic, Policy, and Paradigm Implications

The empirical findings of the study extend beyond the validation of statistical relationships and theoretical propositions to generate broader strategic, governance, and policy implications relevant to the future development of intelligent infrastructure ecosystems. The evidence consistently demonstrates that sustainable infrastructure performance is not determined solely by technological sophistication or capital investment intensity. Rather, sustainable value creation emerges through coordinated interaction among multidimensional accounting systems, governance intelligence, institutional quality, sustainability integration, and digital operational capability. Consequently, the findings support a

fundamental rethinking of how infrastructure projects are designed, governed, evaluated, and managed within emerging economies (Kuruppu et al. ,2022)

A particularly important implication concerns the comparative evidence observed across the sampled countries. Despite differences in economic development levels, governance structures, regulatory frameworks, and technological maturity, the results reveal a remarkably consistent pattern: projects characterized by stronger accounting integration, governance capability, and sustainability coordination systematically outperform projects relying primarily on technological investment. This observation suggests that infrastructure success depends less on the scale of technology deployment and more on the quality of institutional integration supporting that technology as shown in table 6.4.

Table 6.4. Cross-Country Comparative Interpretation

Contextual Dimension	Lower-Performing Projects	Higher-Performing Projects
Accounting Integration	Fragmented reporting systems	Integrated sustainability intelligence
Governance Capability	Administrative coordination	Digital governance intelligence
Sustainability Integration	Compliance-oriented approach	Strategic sustainability architecture
AI Deployment	Isolated technological applications	Governance-embedded intelligence
Public Value Creation	Operational outputs	Long-term societal outcomes

The comparative evidence highlights that intelligent infrastructure ecosystems operate most effectively when accounting systems function as strategic information platforms capable of integrating sustainability, governance, operational, and technological information within a unified decision architecture. This finding is particularly relevant for emerging economies where large-scale infrastructure investments frequently focus on physical assets while underinvesting in governance intelligence and sustainability coordination capabilities.

From a strategic perspective, the findings in Table 6.5 indicate that infrastructure organizations should increasingly view accounting systems as dynamic strategic assets rather than administrative reporting mechanisms. Traditional accounting approaches typically emphasize expenditure control, compliance monitoring, and financial accountability. However, the empirical evidence suggests that future infrastructure competitiveness will depend upon the ability of accounting systems to generate predictive intelligence, support sustainability coordination, facilitate governance integration, and enable long-term value optimization. Consequently, accounting departments may gradually evolve into infrastructure intelligence units supporting strategic decision-making across the project lifecycle.

Table 6.5. Strategic Implications for Infrastructure Governance

Strategic Area	Implication
Accounting Systems	Transition toward sustainability intelligence platforms
Governance Structures	Strengthen digital governance capability
Infrastructure Management	Integrate predictive analytics and AI
Sustainability Strategy	Move beyond compliance toward value creation
Public Policy	Embed public value measurement into infrastructure evaluation

The findings also generate important implications for policymakers. Existing infrastructure evaluation frameworks frequently prioritize construction costs, financial returns, and short-term operational efficiency. While these indicators remain important, the study demonstrates that they capture only a portion of the value generated by intelligent mobility infrastructure systems. Policymakers therefore require broader evaluation frameworks capable of measuring environmental resilience, accessibility enhancement, governance quality, digital transformation, and long-term societal impact. The Sustainable Integrated Value Index (SIVI) developed in this study provides a practical foundation for such multidimensional evaluation systems.

The policy implications are particularly relevant for large-scale smart mobility projects such as intelligent monorail systems, smart rail networks, and digitally integrated transportation infrastructures. The findings suggest that governments should complement physical infrastructure investment with parallel investments in governance intelligence, sustainability accounting capability, institutional coordination, and AI-enabled decision support systems. Such an integrated approach is more likely to maximize long-term public value than infrastructure expansion strategies based solely on engineering and construction considerations (de Bortoli et al. ,2025; Annarelli et al. ,2024)

At the paradigm level, the study supports the emergence of a new accounting perspective referred to as Dynamic Public Value Accounting (DPVA). DPVA represents the culmination of the theoretical and empirical developments presented throughout the study. Under this paradigm, accounting is no longer viewed as a retrospective mechanism focused primarily on documenting historical transactions and financial outcomes. Instead, accounting becomes a forward-looking infrastructure intelligence architecture capable of supporting sustainability governance, predictive resilience, digital transformation, and multidimensional public value creation.

Sustainability Intelligence

The DPVA paradigm integrates sustainability accounting, governance intelligence, institutional capability, digital transformation, and public value theory within a single analytical architecture. Through this integration, accounting evolves from a measurement technology into a strategic capability shaping infrastructure performance and societal

outcomes. This reconceptualization has important implications not only for infrastructure governance but also for the broader future of accounting research.

Overall, the findings demonstrate that the future success of intelligent infrastructure ecosystems will depend increasingly on the ability of organizations and governments to integrate accounting intelligence, sustainability governance, digital capability, and institutional quality within coherent value-creation architectures. By advancing the concepts of MDA, SIVI, DSIAA, and DPVA, the study contributes to a new generation of accounting research focused on the strategic management of sustainable public value within digitally transforming infrastructure environments.

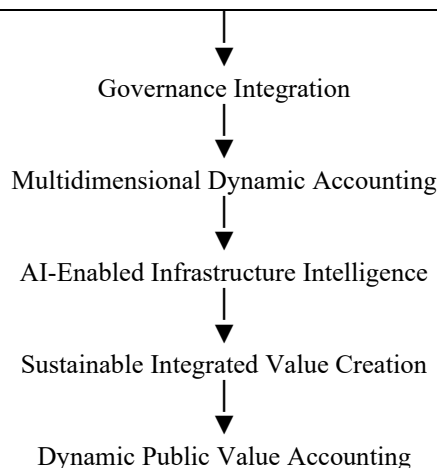


Figure 10. Future Paradigm of Dynamic Public Value Accounting

VII. Conclusion, Strategic Reflections, and Future Research Trajectories

7.1 Reframing the Intellectual Logic of Infrastructure Accounting

The present study began from the recognition that traditional infrastructure accounting systems are increasingly incapable of capturing the multidimensional sustainable value generated by intelligent mobility ecosystems within emerging economies. Conventional accounting frameworks continue to emphasize:

- capital expenditure,
 - operational efficiency,
 - and retrospective financial performance,
- while underestimating the growing importance of:

- sustainability intelligence,
- governance capability,
- AI-enabled operational coordination,
- and long-term public value creation (Bebbington et al., 2024; Larrinaga et al., 2024).

Accordingly, the study proposed a conceptual transformation from traditional infrastructure costing logic toward: **Multidimensional Dynamic Accounting (MDA)**

as an integrated sustainability intelligence architecture embedded directly within smart infrastructure ecosystems.

The empirical findings demonstrated that intelligent monorail systems generate interconnected:

- environmental,
- governance,
- digital,
- strategic,
- and societal value dimensions

that cannot be adequately explained through traditional accounting metrics alone.

7.2 Summary of Empirical and Theoretical Findings

The study provided strong evidence that multidimensional dynamic accounting significantly improves sustainable integrated value creation within intelligent mobility ecosystems. More specifically, the findings demonstrated that:

- governance capability,
- sustainability disclosure quality,
- AI-enabled operational intelligence,
- and institutional quality

collectively shape the effectiveness of sustainable infrastructure systems within emerging economies.

The results additionally revealed that governance capability functions as a strategic moderating mechanism amplifying the effectiveness of sustainability accounting and predictive operational intelligence. Similarly, institutional quality substantially influences the ability of intelligent infrastructure systems to transform digital intelligence into long-term public value outcomes (Bracci et al., 2024; Kaur et al., 2024).

The study further contributed theoretically through the development of:

Dynamic Public Value Accounting

which reconceptualizes accounting as:

A Predictive Sustainability Governance Capability

rather than merely a retrospective financial reporting mechanism.

This conceptual contribution extends sustainability accounting literature by integrating:

- governance intelligence,
- AI-enabled infrastructure systems,
- institutional coordination,
- and multidimensional public value creation

within a unified accounting framework.

7.3 Practical and Policy Implications

The findings of the study generate important implications for:

- policymakers,
- infrastructure authorities,
- sustainability regulators,
- and governance institutions

within emerging economies.

First, the study demonstrates that intelligent infrastructure sustainability depends not solely upon technological modernization, but also upon:

- governance coordination,
- sustainability integration,
- institutional capability,
- and predictive operational intelligence.

Second, the study suggests that accounting systems should increasingly evolve toward:

Real-Time Sustainability Intelligence Architectures

capable of integrating:

- environmental metrics,
- governance analytics,
- AI-enabled operational data,
- and resilience indicators

within unified infrastructure governance systems.

Third, the findings indicate that smart monorail systems can contribute significantly to:

- urban sustainability,
- digital governance modernization,
- congestion reduction,
- climate resilience,
- and public value optimization

when supported by integrated governance intelligence ecosystems (Scobie et al., 2024; Secundo et al., 2024).

Consequently, infrastructure policies within emerging economies should move beyond narrow financial feasibility logic toward broader multidimensional sustainability governance frameworks.

7.4 Limitations of the Study

Despite its theoretical and empirical contributions, the study remains subject to several limitations.

First, the empirical analysis focused primarily on intelligent monorail infrastructure systems within emerging economy contexts. Consequently, the generalizability of the findings to:

- developed economies,
- heavy rail systems,
- or non-transport infrastructure sectors

should be interpreted cautiously.

Second, the multidimensional nature of sustainable public value creates measurement complexity because certain governance and societal outcomes remain partially qualitative and institutionally contextual.

Third, although the study incorporated AI-enabled operational intelligence variables, rapidly evolving technological ecosystems may generate additional governance and accounting dynamics not fully captured within the present framework (Di Vaio et al., 2024; Gürdür Broo et al., 2024).

Finally, institutional asymmetry across emerging economies may influence the stability of governance capability and sustainability coordination mechanisms over time.

7.5 Future Research Trajectories

The present study opens several important avenues for future research.

First, future studies may extend multidimensional dynamic accounting frameworks toward:

- smart energy infrastructure,
- intelligent logistics ecosystems,
- digital public utilities,
- and climate-resilient infrastructure systems.

Second, future accounting research may further investigate how:

- AI-enabled predictive governance,
- machine learning analytics,
- and digital accountability architectures

reshape sustainability accounting systems and infrastructure resilience management.

Third, comparative cross-country studies may provide deeper insight into how institutional quality and governance maturity shape sustainable infrastructure intelligence across different economic environments.

Finally, future research may continue developing:

Dynamic Public Value Accounting

as an emerging accounting paradigm capable of repositioning accounting within:

- sustainability governance,
- smart city ecosystems,
- AI-enabled public administration,
- and intelligent infrastructure transformation processes.

Overall, the study concludes that the future of infrastructure accounting increasingly depends upon its ability to evolve from:

Retrospective Financial Reporting

toward:

Predictive Sustainability Intelligence Embedded Within Dynamic Public Value Ecosystems.

Conflict of Interest Statement

The author declares that there is no conflict of interest regarding the publication of this paper. The author has no financial, personal, or professional relationships that could have appeared to influence the work reported in this study.

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