Journal of Economics, Finance and Management Studies

ISSN (print): 2644-0490, ISSN (online): 2644-0504

Volume 09 Issue 02 February 2026

Article DOI: 10.47191/jefms/v9-i2-29, Impact Factor: 8.317

Page No: 871-893

A Sovereign-Oriented, Decision-Centric Framework for Digital Sustainability Assurance in Supreme Audit Institutions: Empirical and Comparative Evidence from Egypt

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ABSTRACT: This study aims to reconceptualize sustainability assurance in Supreme Audit Institutions (SAIs) by developing a sovereign-oriented, decision-centric digital framework that shifts assurance practices away from report-centric models toward evidence-based evaluation of sustainability-related decisions and impacts. The study positions Egypt as a high-potential sovereign context for institutional design rather than a constrained local case.

Methodology

The research adopts a qualitative, design-oriented methodology combining institutional analysis, comparative review of international sustainability assurance practices, and applied empirical insights from the Egyptian public-sector auditing environment.

Design/Approach

A sovereign digital sustainability assurance framework is developed based on three core pillars: digitally embedded evidence, decision-centric assurance, and impact-oriented evaluation. The framework integrates advanced digital tools—such as data analytics, process mining, and system-based evidence mapping—while remaining compatible with existing legal mandates of SAIs.

Findings

The study finds that sustainability assurance can be effectively conducted without reliance on formal sustainability reporting regimes by leveraging operational data, system logs, and decision trails. Decision-centric digital assurance enables SAIs to evaluate sustainability impacts in real time, enhances audit relevance, and strengthens public value protection without requiring immediate legislative reform.

Originality

This research is among the first to conceptualize sustainability assurance as a sovereign, decision-centric, and report-independent digital function tailored to public-sector audit institutions in emerging economies.

Value

The proposed framework provides SAIs with a scalable and legally compatible pathway to lead sustainability assurance reforms while preserving data sovereignty, institutional autonomy, and public accountability.

Theoretical, Practical, and Social Implications

The study advances sustainability assurance theory beyond disclosure-based paradigms, offers practical guidance for digitally transforming public-sector audits, and supports broader societal objectives related to transparency, efficient resource allocation, and sustainable development.

KEYWORDS: (Revised and Optimized) Digital sustainability assurance; decision-centric assurance; Supreme Audit Institutions; sovereign framework; public-sector auditing; sustainability impacts; public value.

1. INTRODUCTION

1.1 Background and Context

Over the past two decades, public-sector accountability has undergone a fundamental transformation. Traditional models of public auditing, primarily concerned with financial compliance and legality, have progressively expanded to encompass broader

concerns related to sustainability, public value creation, and long-term societal impacts (Broadbent & Guthrie, 2022; Guthrie, Manes-Rossi, & Orelli, 2023). Governments are increasingly expected to demonstrate not only how public resources are spent, but also how public decisions contribute to economic resilience, social well-being, and environmental protection.

In response to these expectations, sustainability reporting has emerged as a dominant accountability mechanism, particularly in the private sector. However, the transfer of reporting-based sustainability models to the public sector remains contested. Prior studies highlight that public-sector sustainability reporting is often fragmented, symbolic, and weakly connected to actual decision-making processes and operational outcomes (Manes-Rossi & Nicolò, 2022; Tiron-Tudor et al., 2021). As a result, formal sustainability reports frequently fail to capture the real sustainability implications of public policies and programs (Gray, 2010).

At the same time, Supreme Audit Institutions (SAIs) face mounting pressure to adapt their assurance practices to digitally transformed governance environments. Digitalization has profoundly reshaped public-sector operations by embedding data generation within information systems, administrative platforms, and service delivery processes (Carnegie, Parker, & Tsahuridu, 2021). Recent audit research suggests that this transformation creates opportunities to move beyond document-based verification toward data-driven and system-embedded assurance models (Alles, 2024; Appelbaum, Kogan, & Vasarhelyi, 2023; Biondi & Bracci, 2018; Hood, 2012).

These challenges and opportunities are particularly salient in emerging economies such as Egypt. Rather than representing a constrained or deficient context, such environments offer a strategic window for institutional redesign, allowing assurance systems to be re-engineered digitally before rigid sustainability reporting regimes become institutionalized (OECD, 2023; World Economic Forum, 2022; World Economic Forum, 2023; United Nations, 2015).

1.2 Statement of the Research Problem

Despite the growing global emphasis on sustainability, many public-sector environments lack mandatory sustainability reporting frameworks. In Egypt, as in many emerging economies, public entities are not legally required to prepare sustainability reports, and SAIs do not possess explicit statutory mandates to audit such reports when they exist. This institutional reality generates a critical accountability gap: sustainability-related public decisions and impacts remain largely unaudited from a systematic assurance perspective (INTOSAI, 2019; European Court of Auditors, 2023).

This gap is further exacerbated by the limited integration of advanced digital technologies into public-sector audit practices. Although vast amounts of operational and administrative data are continuously generated within government information systems, these data are rarely leveraged as primary sources of sustainability assurance evidence (Kokina & Davenport, 2017; Dechow, Myers, & Shakespeare, 2021). Existing sustainability assurance models remain heavily report-centric and poorly aligned with the realities of public governance and digital administration (World Bank, 2022).

Accordingly, the central research problem addressed in this study is the absence of a coherent conceptual and methodological framework that enables SAIs to conduct digital, evidence-based sustainability assurance within their existing legal mandates, without reliance on formal sustainability reporting regimes (Transparency International, 2024).

1.3 Research Objectives and Questions

The primary objective of this study is to develop a **sovereign digital framework** that reconceptualizes sustainability assurance in Supreme Audit Institutions by shifting the focus from report verification to the evaluation of digitally embedded evidence related to public-sector decisions and their sustainability impacts.

To achieve this objective, the study addresses the following research questions:

1. How can sustainability assurance in Supreme Audit Institutions be reconceptualized beyond report-centric models?
2. How can digital technologies enable evidence-based evaluation of sustainability-related public decisions and impacts?
3. How can the Egyptian public-sector audit context be utilized as an applied design setting with relevance for other emerging economies?

1.4 Research Significance

This study is significant on several interrelated levels. Theoretically, it contributes to the sustainability assurance literature by extending assurance concepts beyond disclosure-based paradigms and integrating insights from public accountability, digital transformation, and institutional design theories (Roberts & Scapens, 2020; Power, 2021). It challenges the implicit assumption that sustainability assurance must necessarily be anchored in formal reporting systems.

From a professional perspective, the study offers SAIs a practical pathway to enhance the relevance and timeliness of audit work by leveraging operational data and digital audit tools, thereby strengthening public value protection without immediate legislative reform (INTOSAI, 2020). Institutionally, the research supports policy agendas aimed at modernizing public-sector

governance and aligning audit practices with sustainable development objectives (OECD, 2020; European Commission, 2022; Mazzucato, 2021).

1.5 Research Contribution

This study makes four primary contributions. First, it reconceptualizes sustainability assurance as a digital, evidence-based function centered on public decisions and impacts rather than ex post reporting artifacts. Second, it develops a sovereign assurance framework tailored to the institutional mandates and data sovereignty concerns of SAIs. Third, it advances sustainability assurance theory by embedding digital technologies as foundational elements rather than auxiliary tools. Finally, it positions Egypt as an applied institutional design case, offering transferable insights for SAIs in other emerging economies (Guthrie et al., 2023; Broadbent & Guthrie, 2022).

1.6 Structure of the Paper

The remainder of the paper is organized as follows. Chapter 2 reviews the relevant literature and develops the theoretical foundations of the study. Chapter 3 presents the proposed sovereign digital sustainability assurance framework and formulates the research propositions. Chapter 4 outlines the research methodology and comparative design. Chapter 5 analyzes the empirical and applied findings. Chapter 6 discusses the results, implications, and policy recommendations. Chapter 7 concludes the study and outlines directions for future research.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Sustainability Assurance: Evolution and Conceptual Limitations

The concept of sustainability assurance has evolved primarily within the context of corporate reporting and private-sector accountability. Early sustainability assurance practices emerged as extensions of financial audit methodologies, aiming to enhance the credibility of non-financial disclosures through third-party verification (O'Dwyer, Owen, & Unerman, 2011; Deegan, 2019). These practices were largely shaped by voluntary reporting frameworks such as the Global Reporting Initiative (GRI) and, more recently, integrated reporting initiatives, which positioned sustainability information as an adjunct to traditional financial disclosures (Adams, 2020; Flower, 2015).

Within this literature, sustainability assurance has been predominantly conceptualized as a report-centric activity, focusing on the accuracy, completeness, and consistency of disclosed sustainability metrics (Bebbington, Unerman, & O'Dwyer, 2020). Assurance engagements typically aim to validate whether reported indicators faithfully represent underlying organizational practices, often resulting in limited or moderate assurance statements that mirror financial audit opinions (Tiron-Tudor et al., 2021). While this approach has contributed to improving disclosure discipline, scholars increasingly question its substantive impact on organizational behavior and sustainability outcomes (De Villiers et al., 2021.

A growing body of critical accounting research argues that sustainability reports frequently function as symbolic instruments rather than as mechanisms of genuine accountability (Roberts, 2018; Dumay, La Torre, & Farneti, 2019). Reporting-based assurance may enhance the appearance of transparency while leaving underlying decision-making processes and operational practices largely unexamined. This critique is particularly salient in contexts where sustainability information is selectively disclosed, weakly standardized, or decoupled from core management systems (Bromley & Powell, 2012; Morhardt, 2010; Simnett et al., 2009).

These limitations have prompted calls to rethink sustainability assurance beyond its traditional anchoring in disclosure verification. Scholars emphasize that sustainability challenges—such as climate resilience, social equity, and resource efficiency—are fundamentally embedded in organizational decisions and processes, rather than in ex post narratives (Schaltegger, Hörisch, & Freeman, 2021). Consequently, assurance models that focus exclusively on reported outputs risk overlooking the structural and procedural drivers of sustainability performance (Zorio et al., 2013; Vanstraelen et al., 2014; Barkemeyer et al., 2015; Green & Li, 2012; Michelon et al., 2015).

2.2 Sustainability Assurance in the Public Sector: Institutional Tensions

The transfer of sustainability assurance concepts from the private to the public sector introduces additional complexities. Public-sector organizations operate under distinct accountability regimes characterized by multiple stakeholders, political oversight, and mandates oriented toward public value rather than profit maximization (Broadbent & Laughlin, 2019; Carnegie, Guthrie, & Martin-Sardesai, 2022). Unlike corporations, public entities are rarely driven by market pressures to disclose sustainability information, and sustainability reporting remains largely voluntary or fragmented across jurisdictions (Manes-Rossi & Orelli, 2020).

Existing studies on public-sector sustainability reporting highlight significant variation in scope, quality, and institutionalization. Where such reporting exists, it is often shaped by external donor requirements, international initiatives, or symbolic compliance

rather than by integrated governance practices (Guthrie, Manes-Rossi, & Orelli, 2023). As a result, sustainability assurance in the public sector has struggled to gain methodological coherence or institutional legitimacy.

Supreme Audit Institutions occupy a unique position within this landscape. INTOSAI frameworks emphasize the role of SAIs in promoting transparency, accountability, and public value creation (INTOSAI, 2019). However, these mandates have traditionally been operationalized through financial, compliance, and performance audits, with limited explicit guidance on sustainability assurance (INTOSAI, 2020). Consequently, SAIs face an institutional tension: they are increasingly expected to address sustainability-related concerns, yet lack standardized tools, legal mandates, and reporting infrastructures to do so through conventional assurance models.

Scholars argue that this tension cannot be resolved merely by extending private-sector sustainability assurance templates to public-sector audits (Humphrey, O'Dwyer, & Unerman, 2017). Such extensions risk reinforcing superficial accountability practices that prioritize disclosure over substantive evaluation of public decisions and impacts. Instead, public-sector sustainability assurance requires a conceptual reorientation that aligns with the distinctive governance logics, data environments, and accountability expectations of the state.

2.3 Critiquing Report-Centric Assurance Logics

At the core of the sustainability assurance literature lies an implicit assumption: that credible assurance presupposes the existence of formalized sustainability reports. This assumption has increasingly been challenged. Power (1997, 2021) famously conceptualized auditing as a "ritual of verification," cautioning that the expansion of audit practices can generate an illusion of control without necessarily improving underlying performance. In the sustainability domain, this critique manifests in concerns that assurance engagements may legitimize reporting practices without interrogating their substantive relevance.

Recent studies demonstrate that report-centric assurance models are ill-suited to environments characterized by weak reporting mandates, limited standardization, and rapidly evolving policy objectives—conditions that typify many public-sector and emerging economy contexts (Roberts & Scapens, 2020; OECD, 2023). Under such conditions, the absence of standardized reports does not imply the absence of sustainability-relevant information. Rather, it reflects the dispersion of such information across operational systems, administrative databases, and decision-making processes (Boiral et al., 2019).

This insight has catalyzed interest in alternative assurance logics that prioritize evidence over disclosure. Instead of verifying whether sustainability information has been properly reported, these approaches seek to evaluate whether sustainability considerations are embedded in organizational decisions, resource allocations, and implementation practices (Christensen, Skærbæk, & Tryggestad, 2020). From this perspective, assurance becomes a forward-looking, evaluative function rather than a retrospective validation exercise (Bédard et al., 2019; Free et al., 2009; Free & Murphy, 2015; Brown & Dillard, 2015).

2.4 Digital Auditing and the Emergence of Evidence-Based Assurance

The digital transformation of auditing has fundamentally altered how assurance is conceptualized, executed, and valued. Early digital audit research focused on the use of Computer-Assisted Audit Techniques (CAATs) to improve efficiency and sampling accuracy. However, recent scholarship emphasizes a more profound shift: from document-based verification toward continuous, data-driven, and system-embedded assurance models (Alles, 2015; Vasarhelyi, Kogan, & Tuttle, 2015).

Digital auditing literature highlights that contemporary organizations increasingly generate audit-relevant evidence as a by-product of routine operations. Transaction logs, system records, workflow data, and administrative databases now constitute primary sources of assurance evidence rather than supplementary inputs (Appelbaum, Kogan, & Vasarhelyi, 2020). This shift challenges traditional audit assumptions regarding evidence timing, scope, and reliability, as assurance activities can be conducted closer to real-time and across full data populations rather than limited samples.

In the public sector, digitalization has expanded the availability of operational data related to budgeting, procurement, service delivery, and resource utilization. Government information systems continuously record decisions, approvals, and execution stages, creating traceable decision trails that can be analyzed for sustainability relevance (Mergel, Edelmann, & Haug, 2019; OECD, 2020). Consequently, digital auditing enables auditors to examine how decisions are made and implemented, rather than merely what is disclosed after the fact.

Importantly, the digital audit literature stresses that technology does not simply automate existing audit procedures; it reconfigures the epistemological foundations of assurance. Evidence becomes embedded in systems and processes, and assurance shifts toward pattern recognition, anomaly detection, and causal inference (Kokina & Davenport, 2017; Cao, Chychyla, & Stewart, 2022). This reconfiguration provides a critical foundation for reconceptualizing sustainability assurance as an evidence-based evaluation of decisions and impacts.

2.5 Digital Technologies Enabling Decision- and Impact-Oriented Assurance

Beyond basic data analytics, recent studies identify a range of digital technologies that support more substantive assurance practices. Process mining techniques, for example, allow auditors to reconstruct actual workflows from event logs, revealing deviations between formal procedures and operational realities (Alles et al., 2018). Such techniques are particularly relevant for sustainability assurance, as they expose inefficiencies, resource waste, and compliance gaps embedded within routine public-sector processes.

Advanced analytics and visualization tools further enable auditors to link operational activities with sustainability outcomes. By integrating data across procurement, energy consumption, human resources, and project management systems, auditors can assess the cumulative impacts of public decisions on environmental and social indicators (Kokina, Pachamanova, & Corbett, 2017). These capabilities shift assurance attention from static indicators to dynamic impact trajectories.

The literature on artificial intelligence (AI) in auditing also contributes to this shift, albeit with important caveats. Rather than positioning AI as a replacement for professional judgment, recent research emphasizes AI-augmented auditing, where machine learning models assist auditors in identifying risk patterns and sustainability-relevant anomalies while preserving human oversight and explainability (Davenport & Ronanki, 2018; Appelbaum et al., 2020). Explainable AI approaches are particularly important in the public sector, where transparency and accountability considerations constrain the use of opaque algorithms.

Collectively, these digital technologies enable a form of assurance that is inherently decision- and impact-oriented. Sustainability assurance, from this perspective, evaluates whether sustainability considerations are embedded in policy formulation, resource allocation, and implementation practices, and whether these decisions generate intended public value outcomes (Christensen, Skærbæk, & Tryggestad, 2020). Digital tools thus provide the operational means to realize the conceptual shift away from report-centric assurance models.

2.6 Toward a Sovereign Digital Sustainability Assurance Logic

While digital technologies offer powerful capabilities, the literature cautions against uncritical adoption of technology-driven assurance models. In the public sector, concerns related to legal mandates, institutional autonomy, and data governance significantly shape how digital assurance can be designed and implemented (Kraemer, Dedrick, & Shih, 2009). This has given rise to the notion of digital sovereignty, which emphasizes state control over data, analytical infrastructures, and decision-support systems.

From a governance perspective, sovereignty in assurance implies that audit innovations must remain compatible with existing legal mandates and accountability frameworks of SAIs (INTOSAI, 2019). Rather than importing private-sector sustainability assurance standards wholesale, scholars argue for context-sensitive, design-oriented approaches that align digital assurance practices with public-sector values and institutional realities (Humphrey, O'Dwyer, & Unerman, 2017).

Integrating digital auditing with sustainability assurance therefore requires a sovereign assurance logic—one that balances technological innovation with legal compatibility, institutional legitimacy, and public value objectives. Such a logic reframes sustainability assurance as a state-centered function that evaluates decisions and impacts using digitally embedded evidence, without reliance on formal sustainability reporting regimes.

This emerging perspective directly informs the development of the framework proposed in this study. By synthesizing insights from sustainability assurance, digital auditing, and public-sector governance literatures, the next chapter advances a Sovereign Digital Sustainability Assurance Framework that operationalizes evidence-based, decision-focused, and impact-oriented assurance within Supreme Audit Institutions.

2.7 Theoretical Foundations for Reconceptualizing Sustainability Assurance

The sustainability assurance literature has been predominantly shaped by disclosure-based accountability logics derived from legitimacy theory and stakeholder perspectives. Within this stream, assurance is conceptualized as a mechanism for enhancing the credibility of sustainability disclosures and managing legitimacy risks through external verification (Suchman, 1995; Deegan, 2019; Adams & Larrinaga, 2019). While these approaches have gained prominence in corporate reporting contexts, their relevance to public-sector environments remains limited and contested (Roberts, 2018; Carnegie, Guthrie, & Martin-Sardesai, 2022).

Critical accounting scholars argue that report-centric sustainability assurance often produces symbolic rather than substantive accountability. Sustainability reports may function as instruments of impression management, providing an appearance of transparency while leaving underlying decision-making processes and operational practices largely unexamined (Flower, 2015; Dumay, La Torre, & Farneti, 2019). Bromley and Powell (2012) further demonstrate that such practices frequently lead to organizational decoupling, whereby formal compliance with reporting expectations coexists with unchanged operational behavior (Dowling & Pfeffer, 1975; Oliver, 1991).

In the public sector, these limitations are amplified by the absence of market discipline and by accountability regimes oriented toward public value rather than shareholder interests. Public-sector accountability literature emphasizes that accountability mechanisms should evaluate how public authority and resources are mobilized through decisions, programs, and implementation processes to generate long-term societal outcomes (Bryson, Crosby, & Bloomberg, 2014; Christensen, Skærbæk, & Tryggestad, 2020). However, this perspective has rarely been integrated into sustainability assurance frameworks, which continue to privilege disclosure verification over decision and impact evaluation (Broadbent & Laughlin, 2019; Guthrie, Manes-Rossi, & Orelli, 2023).

Digital auditing research introduces a further theoretical shift by reconceptualizing audit evidence as system-embedded and continuously generated rather than retrospectively assembled. Studies on continuous auditing and audit analytics show that transaction logs, system records, and process data increasingly constitute primary sources of assurance evidence (Alles, 2015; Vasarhelyi, Kogan, & Tuttle, 2015; Appelbaum, Kogan, & Vasarhelyi, 2020). These insights suggest that sustainability assurance can be reoriented toward the evaluation of digitally embedded evidence reflecting public decisions and their operational impacts (Mergel, Edelmann, & Haug, 2019; OECD, 2020; Ostrom, 2010; Waddock, 2008; Young, 2014; Unerman et al., 2018; Larrinaga, 2017).

Table 1. Presents Evolution of Sustainability Assurance Logics

Table 1. Evolution of Sustainability Assurance Logics in the Literature

Dimension	Report-Centric Assurance	Performance-Oriented Assurance	Evidence-Based Digital Assurance
Core focus	Verification of sustainability reports	Evaluation of programs and outputs	Evaluation of decisions, processes, and impacts
Primary evidence	Disclosed narratives and indicators	Aggregated performance data	System logs, operational data, decision trails
Timing of assurance	Ex post	Periodic	Continuous / near real-time
Accountability logic	Legitimacy and transparency	Managerial accountability	Public value and sovereign accountability
Dominant literature	Deegan (2019); Bebbington et al. (2020)	Broadbent & Laughlin (2019)	Alles (2015); Christensen et al. (2020); Appelbaum et al. (2020)

Source: Synthesized from the sustainability assurance, public-sector accountability, and digital auditing literatures.

2.8 Institutional Design, Digital Sovereignty, and Public Accountability

Institutional design theory provides a critical lens for understanding why sustainability assurance frameworks must be adapted to sovereign public-sector contexts. Institutions define the boundaries of legitimate action by structuring mandates, authority, and acceptable forms of evidence (Scott, 2014; Mahoney & Thelen, 2010). For Supreme Audit Institutions, constitutional roles and statutory mandates constrain the direct transplantation of private-sector sustainability assurance standards (INTOSAI, 2019; Humphrey, O'Dwyer, & Unerman, 2017).

The concept of sovereign accountability emphasizes that assurance systems in the public sector must preserve legal compatibility, institutional autonomy, and control over public data. This perspective aligns with emerging debates on digital sovereignty, which caution against reliance on externally governed platforms or opaque algorithmic systems for core accountability functions (Kraemer, Dedrick, & Shih, 2009; Lanzara, 2009). From this standpoint, digital technologies should be embedded within state-controlled infrastructures and aligned with public-sector values rather than imported as standardized technical solutions.

Integrating institutional design theory with public value theory reframes sustainability assurance as a state-centered evaluative function. Rather than focusing on the credibility of disclosed sustainability information, assurance evaluates whether sustainability considerations are embedded in public decisions, resource allocations, and implementation practices, and whether these decisions generate intended societal impacts (Bryson et al., 2014; Christensen et al., 2020; Power, 2021).

2.9 Literature Gap and Positioning of the Study

The synthesis of the reviewed literature reveals a clear and persistent gap. As shown in table 2. Existing sustainability assurance research largely assumes the presence of standardized reporting regimes and under-theorizes how assurance can operate in their

absence (O'Dwyer, Owen, & Unerman, 2011; Tiron-Tudor et al., 2021). At the same time, digital auditing studies rarely extend their analytical insights to sustainability governance or public value evaluation (Alles, 2015; Appelbaum et al., 2020).

Table 2. Literature Gaps and Theoretical Contribution of the Study

Literature Stream	Core Assumptions	Key Limitations	Contribution of This Study
Sustainability assurance	Reports are prerequisites for assurance	Symbolic accountability; disclosure bias	Report-independent, evidence-based assurance
Public-sector auditing	Focus on financial and performance audits	Limited sustainability integration	Decision- and impact-focused assurance
Digital auditing	Technology as efficiency enhancer	Weak linkage to sustainability goals	Digital tools as foundations of assurance logic
Accountability theory	Transparency ensures accountability	Neglect of decision processes	Decision-centric public value evaluation
Institutional design	Stability of mandates	Under-theorized digital change	Sovereign, design-oriented assurance framework

This study addresses this gap by reconceptualizing sustainability assurance as a sovereign, digital, and evidence-based function that evaluates public decisions and their sustainability impacts. By integrating public value theory, institutional design theory, and digital auditing scholarship, the study advances a coherent theoretical foundation for sustainability assurance in Supreme Audit Institutions. This positioning directly informs the framework developed in Chapter 3.

3. A SOVEREIGN DIGITAL FRAMEWORK FOR RECONCEPTUALIZING SUSTAINABILITY ASSURANCE AND DEVELOPMENT OF PROPOSITIONS

3.1 Introduction and Rationale

The preceding literature review demonstrates that prevailing sustainability assurance models remain largely constrained by report-centric logics and disclosure-based accountability assumptions. Such models are ill-suited to public-sector environments where sustainability reporting is not legally mandated, where accountability is institutional rather than market-driven, and where sustainability impacts are embedded in complex policy decisions and operational processes (Broadbent & Laughlin, 2019; Carnegie et al., 2022; Guthrie et al., 2023). At the same time, digital transformation has profoundly reshaped public administration, embedding audit-relevant evidence within information systems, workflows, and decision platforms (Alles, 2015; Vasarhelyi et al., 2015).

This chapter develops a Sovereign Digital Sustainability Assurance Framework (SDSAF) that reconceptualizes sustainability assurance as a decision-, evidence-, and impact-oriented evaluative function conducted within the institutional mandates of Supreme Audit Institutions (SAIs). Rather than extending private-sector sustainability assurance standards, the framework adopts a design-oriented public-sector logic grounded in public value theory, institutional design, and digital auditing scholarship (Bryson et al., 2014; Scott, 2014; Appelbaum et al., 2020).

3.2 Conceptual Foundations of the Sovereign Digital Sustainability Assurance Framework

3.2.1 Public Value and Decision-Centric Accountability

Public value theory provides a foundational lens for reconceptualizing sustainability assurance in the public sector. Unlike shareholder-oriented accountability models, public value perspectives emphasize evaluating how public authority, resources, and discretion are mobilized to achieve long-term societal outcomes (Moore, 1995; Bryson et al., 2014). Sustainability, from this viewpoint, is not a reporting outcome but a decision property—embedded in how policies are formulated, resources allocated, and programs implemented (Christensen et al., 2020; Moore, 1995; Ahrens et al., 2021).

Accordingly, sustainability assurance must assess whether sustainability considerations are systematically incorporated into public-sector decision processes and whether these decisions generate intended economic, social, and environmental impacts (Roberts & Scapens, 2020; Power, 2021). This logic shifts assurance attention from disclosed indicators to decision rationales, trade-offs, and execution pathways (Porter & Kramer, 2011; PSAARN, 2021).

3.2.2 Digital Auditing and Embedded Evidence

Digital auditing research demonstrates that contemporary audit evidence increasingly originates within digital infrastructures rather than ex post documentation (Alles, 2015; Appelbaum et al., 2020). Transaction logs, approval workflows, procurement platforms, budgeting systems, and performance dashboards generate continuous streams of data reflecting actual organizational behavior (Mergel et al., 2019).

In sustainability contexts, these digital traces capture how sustainability objectives are operationalized—or neglected—across public-sector processes (Cao et al., 2022; OECD, 2020). Digital assurance thus enables evaluative scrutiny of what was decided, how it was implemented, and with what impacts, providing a robust alternative to report-based verification.

3.2.3 Sovereignty, Institutional Mandates, and Data Governance

The framework explicitly incorporates sovereignty as a core design principle. Sovereignty here denotes legal compatibility, institutional autonomy, and control over data and analytical infrastructures within the mandate of SAIs (INTOSAI, 2019; Kraemer et al., 2009). This principle guards against uncritical adoption of externally designed sustainability standards or opaque algorithmic systems that may undermine public accountability (Lanzara, 2009; Henfridsson et al., 2018).

3.3 Structure of the Sovereign Digital Sustainability Assurance Framework

The proposed framework comprises four interrelated layers: (1) Digital Evidence Layer, (2) Decision Evaluation Layer, (3) Impact Assessment Layer, and (4) Sovereign Accountability Layer. As shown in table 3.

3.3.1 Digital Evidence Layer

This layer identifies and structures sustainability-relevant evidence embedded within public-sector information systems. Such evidence includes procurement records, budget execution data, energy consumption logs, human resource systems, and project management platforms (Alles et al., 2018; Kokina & Davenport, 2017). Unlike sustainability reports, these data sources are operational by design and less susceptible to impression management (Dumay et al., 2019).

3.3.2 Decision Evaluation Layer

At this stage, auditors evaluate whether sustainability criteria are explicitly incorporated into policy formulation, resource allocation, and implementation decisions. Decision trails reconstructed through process mining and workflow analytics allow auditors to assess alignment between stated sustainability objectives and actual decision practices (Christensen et al., 2020; Power, 2021).

3.3.3 Impact Assessment Layer

This layer links decisions and processes to observable sustainability impacts. By integrating operational data with environmental, social, and economic performance indicators, auditors assess cumulative and long-term effects of public actions (Schaltegger et al., 2021; Krajnc & Glavič, 2005).

3.3.4 Sovereign Accountability Layer

The final layer situates assurance findings within the legal and institutional mandate of SAIs. Assurance conclusions are framed in terms of public value protection, policy effectiveness, and governance improvement rather than compliance with external reporting standards (INTOSAI, 2020; OECD, 2023).

Table 3. The Sovereign Digital Sustainability Assurance Framework

Layer	Core Focus	Primary Evidence	Assurance Objective
Digital Evidence	System-embedded data	Logs, workflows, databases	Reliable, non-symbolic evidence
Decision Evaluation	Policy and managerial decisions	Decision trails, approvals	Sustainability integration
Impact Assessment	Outcomes and effects	Performance & impact data	Public value generation
Sovereign Accountability	Institutional mandate	Audit judgments	Legitimate public assurance

3.4 Operational Logic and Assurance Process

The assurance process begins with mapping sustainability-relevant decision domains, followed by identification of corresponding digital evidence sources. Advanced analytics, visualization, and process mining tools support systematic evaluation of decision consistency and impact pathways (Kokina et al., 2017; Cao et al., 2022). Importantly, professional judgment remains central, with digital tools augmenting rather than replacing auditor expertise (Brown-Liburd et al., 2022).

This process allows SAIs to conduct sustainability assurance without reliance on formal sustainability reports, thereby overcoming institutional and legal constraints prevalent in many emerging economies (COSO, 2013; COSO, 2017; ISO, 2018; ISO, 2021; AASB, 2013; IFAC, 2018).

Table 4. Presents Comparison Report-Based and Sovereign Digital Sustainability Assurance

Table 4. Comparison Between Report-Based and Sovereign Digital Sustainability Assurance

Dimension	Report-Based Assurance	Sovereign Digital Assurance
Primary object	Sustainability reports	Decisions and impacts
Evidence source	Disclosures	Digital operational data
Timing	Retrospective	Continuous
Legal dependency	Reporting mandates	Existing audit mandates
Accountability focus	Transparency	Public value

3.5 Development of Research Propositions

Drawing on the proposed framework, the study advances the following propositions:

P1: Digital, system-embedded evidence enables sustainability assurance independent of formal sustainability reporting regimes (Alles, 2015; Appelbaum et al., 2020).

P2: Decision-focused assurance provides a more substantive evaluation of sustainability performance than disclosure-based assurance in public-sector contexts (Christensen et al., 2020; Power, 2021).

P3: Sovereign assurance frameworks enhance institutional legitimacy and applicability of sustainability assurance within SAIs (INTOSAI, 2019; Kraemer et al., 2009).

P4: Integrating public value theory with digital auditing strengthens the capacity of SAIs to evaluate long-term sustainability impacts (Bryson et al., 2014; Schaltegger et al., 2021).

3.6 Chapter Summary

This chapter developed a Sovereign Digital Sustainability Assurance Framework that reconceptualizes sustainability assurance as a digitally enabled, decision- and impact-oriented public-sector function. Grounded in public value theory, institutional design, and digital auditing research, the framework provides a coherent theoretical and operational foundation for sustainability assurance within SAIs. The next chapter outlines the research methodology and comparative design used to examine the applicability of this framework in the Egyptian context and beyond.

4. RESEARCH METHODOLOGY AND COMPARATIVE DESIGN

4.1 Methodological Orientation and Research Logic

This study adopts a design-oriented qualitative research methodology aimed at developing, refining, and analytically validating a sovereign digital sustainability assurance framework for Supreme Audit Institutions (SAIs). Unlike hypothesis-testing studies that seek statistical generalization, design-oriented research focuses on producing analytically grounded frameworks that address complex institutional problems and generate transferable insights across contexts (Eisenhardt, 1989; Dubois & Gadde, 2002; Eisenhardt & Graebner, 2007).

The methodological logic of this study is guided by analytical generalization rather than empirical representativeness. The objective is not to measure sustainability performance quantitatively, but to examine how sustainability assurance can be reconceptualized and operationalized under specific institutional constraints, particularly in public-sector environments lacking formal sustainability reporting mandates (Yin, 2018; Flyvbjerg, 2006).

This approach is especially appropriate for sustainability assurance research, where institutional heterogeneity, legal mandates, and governance structures significantly shape assurance practices (Humphrey & Scapens, 1996; Carnegie et al., 2022). Accordingly, the study integrates conceptual design with applied empirical insights to bridge theory and practice.

Beyond its alignment with analytical generalization, the design-oriented qualitative methodology adopted in this study is particularly suitable for addressing emergent and ill-structured accountability challenges in the public sector. Sustainability assurance in SAIs represents a “wicked problem,” characterized by ambiguous objectives, evolving policy priorities, and fragmented evidence structures (Rittel & Webber, 1973; Head & Alford, 2015). Under such conditions, explanatory or hypothesis-driven research designs risk oversimplifying institutional complexity and overlooking the contextual contingencies that shape assurance feasibility.

Design-oriented research allows the study to move beyond describing existing practices toward actively shaping alternative assurance logics that are institutionally viable and normatively grounded (Van Aken, 2004; Avenier & Thomas, 2015). Rather than treating the Egyptian context as a bounded empirical case, the methodological logic treats it as a generative design setting through which transferable insights can be derived for other SAIs facing similar governance constraints. This reinforces the suitability of analytical generalization, whereby theoretical propositions are refined through their coherence with observed institutional realities rather than through statistical inference (Yin, 2018).

4.2 Research Design: Design-Oriented and Comparative Approach

4.2.1 Design-Oriented Research Perspective

Design-oriented research emphasizes the creation and evaluation of artifacts—such as frameworks, models, or methodologies—that address real-world problems while contributing to theoretical knowledge (Ahrens & Chapman, 2006; Langley, 1999). In the context of this study, the primary artifact is the Sovereign Digital Sustainability Assurance Framework developed in Chapter 3.

The framework is iteratively informed by:

1. Theoretical insights from sustainability assurance, public value, and digital auditing literatures;
2. Institutional characteristics of SAIs;
3. Observed practices and constraints in public-sector audit environments.

This iterative process aligns with the systematic combining approach, whereby theory and empirical observations are continuously refined in tandem (Dubois & Gadde, 2002; George & Bennett, 2005; Ragin, 2014; OECD, 2020; OECD, 2023; Denzin & Lincoln, 2018; Patton, 2015)

An important feature of design-oriented research is its emphasis on internal coherence between problem definition, artifact construction, and evaluative logic. In sustainability assurance research, coherence is often undermined when conceptual frameworks are developed independently of the legal and operational environments in which they are expected to function (Ahrens & Chapman, 2006; Lukka, 2014). The present study addresses this challenge by embedding institutional constraints—such as mandate boundaries, data access rights, and audit authority—directly into the framework design.

Furthermore, the iterative nature of systematic combining facilitates reflexive engagement with the literature. Rather than treating theory as an exogenous input, the study continuously re-evaluates theoretical assumptions in light of public-sector auditing realities, thereby avoiding normative bias toward private-sector assurance templates (Lukka & Modell, 2017). This approach strengthens the epistemic credibility of the framework by ensuring that its core constructs—digital evidence, decision-centric assurance, and sovereign accountability—remain empirically plausible and institutionally grounded.

4.2.2 Comparative Institutional Design

To enhance analytical robustness, the study employs a comparative institutional design. Rather than conducting multiple full case studies, the research compares the Egyptian public-sector audit environment with selected international SAI practices documented in prior studies and institutional reports (George & Bennett, 2005; Ragin, 2014).

Egypt is positioned as an applied institutional design context, not as an exceptional or deficient case. This positioning allows the framework to be examined under realistic legal and operational constraints common to many emerging economies, while facilitating comparison with more institutionalized sustainability assurance practices in developed jurisdictions (OECD, 2023; INTOSAI, 2020).

4.3 Case Context Selection and Justification

The Egyptian public-sector audit environment provides a theoretically and practically relevant context for examining sovereign digital sustainability assurance. Three key characteristics justify this selection:

First, sustainability reporting is not legally mandated for most public-sector entities, creating a context where report-based assurance is infeasible (INTOSAI, 2019). Second, SAIs operate under clearly defined constitutional and statutory mandates, making sovereignty and legal compatibility central design constraints (Humphrey et al., 2017). Third, public administration in Egypt has undergone substantial digitalization, generating extensive operational data suitable for evidence-based assurance (OECD, 2020).

These characteristics render Egypt an analytically rich context for examining how sustainability assurance can be operationalized through digital evidence and decision evaluation rather than through formal reporting infrastructures.

4.4 Data Sources and Evidence Base

The study draws on multiple qualitative data sources to support analytical triangulation (Denzin & Lincoln, 2018). These sources include as shown in table 5.

- Official audit mandates, laws, and regulatory documents governing SAI responsibilities;
- Publicly available audit reports, performance audit guidelines, and strategic documents;
- International SAI guidance and comparative reports (e.g., INTOSAI, OECD);
- Secondary documentation on digital government systems and public-sector processes.

Importantly, the study does not rely on proprietary or confidential data. Instead, it focuses on institutional evidence structures and publicly documented practices, consistent with the design-oriented research objective.

Table 5. Data Sources and Analytical Purpose

Data Source	Nature of Data	Analytical Purpose
Legal and regulatory texts	Institutional documents	Mandate and sovereignty analysis
Audit guidelines and reports	Public audit outputs	Assurance practice mapping
International SAI reports	Comparative benchmarks	Cross-context comparison
Digital government documentation	System descriptions	Evidence availability assessment

The reliance on publicly available and institutional documentation also enhances the transparency and replicability of the research design. In public-sector auditing research, access to confidential audit files is often restricted, raising concerns about data opacity and selective disclosure (Bringselius, 2014). By grounding the analysis in openly accessible legal texts, audit guidelines, and international standards, the study mitigates these concerns while aligning with ethical principles of public accountability research.

Moreover, the diversity of data sources supports methodological triangulation not through data volume but through functional complementarity. Legal documents clarify the boundaries of legitimate audit action, audit reports illustrate operational practices, and international guidance provides comparative benchmarks for evaluative judgment (Patton, 2015). This triangulation strengthens construct validity by ensuring that the proposed framework is simultaneously legally feasible, operationally relevant, and internationally intelligible.

4.5 Analytical Procedures

The analysis follows a structured, multi-stage procedure:

1. Institutional Mapping: Identification of legal mandates, accountability structures, and digital infrastructures relevant to sustainability assurance (Scott, 2014; Mahoney & Thelen, 2010).
2. Evidence Mapping: Classification of sustainability-relevant digital evidence embedded within public-sector systems (Alles, 2015; Appelbaum et al., 2020).
3. Framework Application: Analytical application of the proposed framework to the Egyptian context to assess feasibility and internal coherence.
4. Comparative Reflection: Comparison of insights with international SAI practices documented in prior literature and institutional guidance (INTOSAI, 2020; OECD, 2023).

This procedure ensures methodological transparency and analytical rigor while avoiding over-claiming empirical validation Scott, 2014; Mahoney & Thelen, 2010; Creswell & Poth, 2018).

4.6 Validity, Reliability, and Analytical Generalization

In qualitative and design-oriented research, validity is established through theoretical coherence, transparency of analytical procedures, and consistency between research questions, methods, and conclusions (Creswell & Poth, 2018). This study enhances validity by grounding the framework in well-established theories and by explicitly articulating design assumptions.

Reliability is addressed through clear documentation of data sources and analytical steps, enabling replication at the conceptual level rather than at the level of specific empirical observations (Yin, 2018). Analytical generalization is achieved by demonstrating how the framework addresses institutional conditions common across many public-sector environments, particularly in emerging economies (Flyvbjerg, 2006).

In design-oriented public-sector research, rigor is achieved not by predictive accuracy but by explanatory power and practical plausibility (Van de Ven, 2007). The study's emphasis on analytical transparency allows readers and practitioners to trace how conclusions are derived from institutional conditions and theoretical premises. This traceability is particularly important for sustainability assurance, where evaluative judgments often involve normative considerations and professional discretion.

By explicitly acknowledging the limits of empirical representativeness, the study avoids over-claiming generalizability. Instead, it demonstrates how the framework addresses structural conditions—such as absent reporting mandates and digitally mediated governance—that are widely shared across emerging economies. This form of analytical generalization enhances the framework's relevance while respecting methodological boundaries (Tsang, 2014).

Table 6. Presents Methodological Quality Criteria

Table 6. Methodological Quality Criteria

Criterion	Approach in This Study
Construct validity	Theory-driven framework design
Internal coherence	Systematic combining

Criterion	Approach in This Study
Reliability	Transparent analytical procedures
Generalizability	Analytical, not statistical

4.7 Ethical Considerations

The study relies exclusively on publicly available documents and secondary sources, ensuring compliance with ethical research standards. No personal data or confidential institutional information is used, and all interpretations are presented at an institutional rather than individual level.

4.8 Chapter Summary

This chapter outlined the design-oriented and comparative methodology underpinning the study. By positioning Egypt as an applied institutional design context and employing analytical generalization, the methodology provides a robust foundation for examining the applicability of the proposed sovereign digital sustainability assurance framework. The next chapter presents the applied analysis and findings derived from this methodological approach.

5. APPLIED ANALYSIS AND FINDINGS

5.1 Introduction

This chapter presents the applied analysis and findings derived from analytically applying the Sovereign Digital Sustainability Assurance Framework (SDSAF) to the Egyptian public-sector audit context. Consistent with the design-oriented methodology outlined in Chapter 4, the analysis does not aim to measure sustainability performance quantitatively. Instead, it examines how sustainability assurance can be operationalized in practice through digitally embedded evidence, decision evaluation, and impact assessment within existing SAI mandates (Yin, 2018; Flyvbjerg, 2006; Mergel et al., 2019; Pollitt & Bouckaert, 2017).

The findings are structured around three analytical dimensions that correspond directly to the framework layers developed in Chapter 3:

(1) digital evidence availability,
(2) decision-centric assurance feasibility, and
(3) sustainability impact evaluability.

The applied analysis presented in this chapter should be interpreted as an analytical demonstration rather than an evaluative judgment of Egyptian public-sector sustainability performance. The objective is not to rank or benchmark institutions, but to assess whether sustainability assurance can be meaningfully operationalized using existing digital infrastructures and audit mandates. This distinction is critical, as conflating assurance feasibility with performance evaluation risks misinterpreting the purpose of design-oriented application (Van Aken, 2004).

By analytically applying the framework, the study illustrates how SAIs can reposition sustainability assurance upstream in the governance cycle, thereby enhancing its relevance for policy learning and institutional improvement. This orientation aligns with contemporary perspectives on performance auditing, which emphasize learning, foresight, and governance enhancement rather than ex post compliance assessment (Pollitt & Bouckaert, 2017).

5.2 Mapping Digital Evidence for Sustainability Assurance

The first analytical step involved mapping sustainability-relevant digital evidence embedded within public-sector information systems. As shown in table 7. Consistent with digital auditing research, the analysis confirms that a substantial volume of audit-relevant evidence is generated continuously as a by-product of routine governmental operations (Alles, 2015; Vasarhelyi et al., 2015; Appelbaum et al., 2020; Head, 2010).

In the Egyptian context, digital government platforms related to budgeting, procurement, payroll, project management, and service delivery produce transaction logs, approval records, and workflow data that reflect actual operational behavior rather than ex post representations (OECD, 2020; Mergel et al., 2019). These data sources are institutionally legitimate, legally accessible to SAIs, and less susceptible to symbolic manipulation than sustainability reports (Dumay et al., 2019; Dumay et al., 2019).

Importantly, the analysis reveals that sustainability-relevant evidence is distributed across systems rather than consolidated in reporting outputs. Environmental, social, and economic implications of public action are embedded in procurement criteria, resource allocation decisions, and implementation practices rather than explicitly labeled as "sustainability data" (Christensen et al., 2020; Janvrin & Watson, 2017; Salijeni et al., 2019).

The dispersion of sustainability-relevant evidence across multiple information systems reflects the inherently cross-cutting nature of sustainability in the public sector. Unlike financial outcomes, sustainability impacts rarely correspond to a single program or budget line; instead, they emerge from interactions among procurement decisions, resource allocation mechanisms, and implementation practices (Head, 2010; Christensen et al., 2020). Digital evidence mapping therefore functions not only as a technical exercise but also as an analytical lens for understanding governance interdependencies (Earley, 2015).

This finding challenges the assumption that the absence of consolidated sustainability reports implies weak accountability capacity. On the contrary, the richness of system-generated data suggests that accountability deficits are often analytical rather than informational. Digital assurance tools enable auditors to reassemble dispersed evidence into coherent evaluative narratives that reflect how sustainability considerations are operationalized in practice (Mergel et al., 2019; Janssen et al., 2020).

Table 7. Digital Evidence Sources for Sustainability Assurance

Public-Sector System	Embedded Evidence	Sustainability Relevance
Budget execution systems	Allocation and reallocation records	Economic sustainability, intergenerational equity (Fischer & Rozen, 2020
Procurement platforms	Tender criteria, supplier selection	Environmental and social standards (PWC, 2022)
Project management systems	Milestones, delays, cost overruns	Resource efficiency and impact (Rikhardsson & Yigitbasioglu, 2018)
HR and payroll systems	Employment patterns, incentives	Social sustainability (Rozario & Vasarhelyi, 2018)
Energy and asset systems	Consumption and utilization data	Environmental sustainability Dai & (Vasarhelyi, 2017)

Source: Analytical synthesis based on digital auditing and public-sector governance literature (Alles, 2015; OECD, 2020; Kshetri, 2018).

5.3 Decision-Centric Sustainability Assurance Findings

Applying the framework's decision-evaluation layer demonstrates that sustainability assurance can be meaningfully conducted by examining decision trails rather than reported outcomes. Process-oriented analysis shows that sustainability considerations—when present—are most visible at critical decision points such as budget approvals, procurement specifications, and project prioritization stages (Power, 2021; Christensen et al., 2020).

The findings indicate that traditional audit practices often assess compliance after implementation, whereas decision-centric digital assurance allows auditors to evaluate whether sustainability criteria were considered before commitments were made. This temporal shift significantly enhances the relevance of assurance, as it aligns audit scrutiny with policy formulation rather than retrospective justification (Roberts & Scapens, 2020; Feng et al., 2015).

Moreover, decision-focused analysis reduces reliance on subjective sustainability narratives and instead emphasizes traceable, system-recorded evidence. This finding directly supports the proposition that sustainability assurance can operate independently of formal sustainability reporting regimes (Alles, 2015; Appelbaum et al., 2020; Hales et al., 2020).

Decision-centric assurance also has important implications for auditor independence and professional judgment. By focusing on documented decision trails rather than self-reported narratives, auditors reduce reliance on managerial representations and enhance evidential robustness (Power, 2021). At the same time, evaluating decision rationales requires auditors to exercise interpretive judgment, particularly when sustainability trade-offs involve competing policy objectives.

This balance between digital traceability and professional discretion aligns with emerging audit scholarship emphasizing "augmented judgment" rather than automation-driven objectivity (Brown-Liburd et al., 2022). Digital tools support the identification of critical decision points, but evaluative conclusions remain grounded in institutional knowledge and public value considerations.

5.4 Assessing Sustainability Impacts through Digital Evidence

The third analytical dimension links decisions and processes to observable sustainability impacts. By integrating operational data with performance and outcome indicators, the framework enables auditors to evaluate how decisions translate into impacts over time (Schaltegger et al., 2021; Krajnc & Glavič, 2005).

The analysis demonstrates that while not all sustainability impacts are immediately quantifiable, digital evidence supports the assessment of impact trajectories, such as cost escalation, resource inefficiency, or service delivery disparities. These trajectories provide a more realistic basis for sustainability evaluation than static indicators reported ex post (Dechow et al., 2021).

Crucially, the findings show that impact-oriented assurance does not require full sustainability measurement systems. Instead, it relies on analytical integration of existing data sources, professional judgment, and institutional knowledge—consistent with public-sector audit realities (INTOSAI, 2020; Brown-Liburd et al., 2022).

Table 8. Presents the Traus Forming from Digital Evidence to Sustainability Outcomes

Table 8. From Digital Evidence to Sustainability Assurance Outcomes

Analytical Stage	Assurance Focus	Output
Evidence mapping	Availability and reliability of data	Assurance scope definition
Decision evaluation	Sustainability integration in decisions	Governance insights
Impact assessment	Consequences of public action	Public value assessment
Sovereign framing	Mandate-aligned conclusions	Legitimate audit judgments

5.5 Institutional and Sovereign Implications of the Findings

The applied analysis confirms that sustainability assurance can be operationalized within existing SAI mandates without legislative reform. By framing assurance around decisions, impacts, and public value, SAIs can avoid jurisdictional conflicts associated with auditing non-mandated sustainability reports (INTOSAI, 2019; Humphrey et al., 2017).

From a sovereignty perspective, the findings highlight the importance of maintaining state control over data, analytical tools, and evaluative judgments. Digital assurance enhances, rather than undermines, institutional autonomy when designed within sovereign governance frameworks (Kraemer et al., 2009; OECD, 2023).

From an institutional perspective, the findings underscore that sovereignty in sustainability assurance is not merely a legal constraint but an enabling condition. When assurance frameworks are aligned with constitutional mandates and data governance norms, they are more likely to be adopted and sustained over time (Scott, 2014; Bringselius, 2018). The sovereign framing of digital assurance thus enhances legitimacy by situating sustainability evaluation within recognized audit roles rather than external reporting regimes.

Furthermore, the emphasis on mandate-compatible assurance mitigates the risk of audit overreach, a concern frequently raised in debates about expanding SAI responsibilities (Humphrey et al., 2017). By focusing on decisions, impacts, and public value, SAIs can contribute meaningfully to sustainability governance without encroaching on policy-making prerogatives.

5.6 Summary of Key Findings

The applied analysis yields four core findings:

1. Sustainability-relevant digital evidence is widely available in public-sector systems despite the absence of formal sustainability reporting.
2. Decision-centric assurance provides more substantive sustainability evaluation than disclosure-based approaches.
3. Impact assessment can be conducted through integrated analysis of operational data without comprehensive sustainability metrics.
4. Sovereign digital assurance is institutionally feasible and legally compatible for SAIs in emerging economies.

These findings provide empirical-analytical support for the framework proposed in Chapter 3 and form the basis for the discussion, implications, and recommendations developed in Chapter 6.

6. DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Discussion of Findings in Relation to the Literature

The findings presented in Chapter 5 provide strong empirical–analytical support for recent critical strands in the sustainability assurance literature that challenge the dominance of report-centric accountability models. Consistent with prior critiques, the results demonstrate that sustainability assurance grounded exclusively in formal reporting frameworks risks producing symbolic transparency while neglecting the substantive evaluation of public decisions and operational practices (Flower, 2015; Dumay, La Torre, & Farneti, 2019; Roberts, 2018).

The evidence that sustainability-relevant information is widely embedded within public-sector digital systems aligns with digital auditing studies emphasizing the shift from document-based to system-embedded assurance (Alles, 2015; Vasarhelyi, Kogan,

& Tuttle, 2015; Appelbaum, Kogan, & Vasarhelyi, 2020). However, this study extends the literature by demonstrating that such embedded evidence is not merely audit-supportive but can function as the primary foundation for sustainability assurance in the absence of formal sustainability reports. This finding directly addresses a gap identified in prior public-sector sustainability research, which often assumes that assurance presupposes the existence of standardized sustainability disclosures (Tiron-Tudor et al., 2021; Guthrie, Manes-Rossi, & Orelli, 2023; (Broadbent & Laughlin, 2019; Hopper et al., 2017; Tucker & Parker, 2015).

Furthermore, the decision-centric orientation of the applied analysis responds to longstanding concerns that sustainability assurance rarely influences actual managerial or policy behavior (Bebbington, Unerman, & O'Dwyer, 2020). By focusing on decision trails and approval processes rather than ex post indicators, the findings suggest that assurance can be repositioned upstream in the governance cycle, where sustainability trade-offs are actively negotiated and institutionalized (Power, 2021; Roberts & Scapens, 2020). This reinforces recent calls for assurance models that are temporally aligned with decision-making rather than retrospective justification (Christensen, Skærbæk, & Tryggestad, 2020).

In the public-sector context, the findings resonate with literature emphasizing that accountability is multidimensional and cannot be reduced to disclosure alone (Broadbent & Laughlin, 2019; Carnegie, Guthrie, & Martin-Sardesai, 2022). The applied results show that sustainability assurance can be meaningfully conducted even where reporting mandates are weak or absent, provided that auditors leverage operational data and institutional knowledge. This challenges the implicit normative bias in parts of the sustainability assurance literature that equate accountability progress with expanded reporting requirements (Adams & Larrinaga, 2019).

Overall, the findings contribute to the literature by empirically substantiating an alternative assurance logic—one that is evidence-based, decision-focused, and institutionally grounded—and by demonstrating its applicability in a real public-sector governance environment.

6.2 Discussion of Findings in Relation to Theoretical Perspectives

From a theoretical standpoint, the findings offer important insights into the limitations of legitimacy- and transparency-based accountability theories when applied to public-sector sustainability assurance. Legitimacy theory traditionally conceptualizes assurance as a mechanism for enhancing organizational credibility through disclosure (Suchman, 1995; Deegan, 2019). However, the applied analysis indicates that legitimacy in public-sector contexts is less dependent on formal sustainability narratives and more closely tied to the perceived quality of public decisions and governance outcomes.

The findings align more closely with public value theory, which emphasizes evaluating how public authority and resources are mobilized to generate long-term societal benefits (Moore, 1995; Bryson, Crosby, & Bloomberg, 2014). By demonstrating that sustainability assurance can assess the integration of sustainability considerations into decision-making and implementation processes, the study reinforces the relevance of public value theory as a foundational lens for public-sector assurance (Christensen et al., 2020; Löhlein, 2019).

Institutional theory further helps explain why report-centric sustainability assurance models face resistance in public-sector environments. Institutions structure what forms of evidence and evaluation are considered legitimate, and SAIs operate within legally defined mandates that privilege certain accountability practices over others (Scott, 2014; Mahoney & Thelen, 2010). The findings suggest that assurance models aligned with existing institutional logics—such as evaluating decisions, resource allocation, and outcomes—are more likely to gain acceptance and durability than externally imposed reporting standards (Humphrey, O'Dwyer, & Unerman, 2017; IAASB, 2020).

Digital auditing theory provides the final theoretical anchor. Prior studies argue that digitalization reshapes the epistemology of auditing by embedding evidence within systems and processes (Alles, 2015; Appelbaum et al., 2020). This study extends that insight by showing how digital evidence enables a reconfiguration of sustainability assurance itself, transforming it from a disclosure-verification activity into a continuous evaluative function centered on decisions and impacts. In doing so, the findings bridge digital auditing theory with sustainability governance in a way that has been largely absent from prior research (IAASB, 2021).

6.3 Discussion of the Validity of the Propositions

The applied findings provide consistent support for the research propositions developed in Chapter 3. As presented in table Proposition P1, which posits that digital, system-embedded evidence enables sustainability assurance independent of formal sustainability reporting, is strongly validated by the evidence mapping and decision-trail analysis. Prior digital auditing studies argue that audit-relevant evidence increasingly originates within operational systems rather than ex post documentation (Alles, 2015; Appelbaum, Kogan, & Vasarhelyi, 2020), and the findings extend this logic explicitly to sustainability assurance contexts.

Proposition P2, asserting that decision-focused assurance offers more substantive sustainability evaluation than disclosure-based assurance in the public sector, is also supported. The analysis demonstrates that examining sustainability integration at decision points—such as budgeting, procurement, and project approval—provides earlier and more meaningful insights than post hoc sustainability narratives (Christensen, Skærbæk, & Tryggestad, 2020; Power, 2021). This confirms critiques that disclosure-oriented assurance often fails to influence real governance behavior (Bebbington, Unerman, & O'Dwyer, 2020).

Proposition P3 relates to the institutional legitimacy of sovereign assurance frameworks. The findings indicate that framing sustainability assurance within existing SAI mandates enhances acceptance and feasibility, consistent with institutional theory arguments regarding mandate compatibility and organizational legitimacy (Scott, 2014; Humphrey, O'Dwyer, & Unerman, 2017). Finally, Proposition P4, which integrates public value theory with digital auditing, is supported by evidence showing that impact-oriented assurance aligns sustainability evaluation with public value creation rather than symbolic transparency (Bryson et al., 2014; Schaltegger, Hörisch, & Freeman, 2021).

6.4 Discussion in Light of Comparative and International Evidence

The findings resonate strongly with comparative and international evidence from SAIs operating in different institutional environments. Studies from European and OECD contexts indicate that even where sustainability reporting is more institutionalized, SAIs increasingly rely on performance audits, data analytics, and system-based evidence to assess sustainability-related policies (European Court of Auditors, 2023; OECD, 2023). This convergence suggests that the proposed sovereign digital assurance logic is not contextually isolated but reflects broader global shifts in public-sector auditing.

However, the Egyptian context highlights an important distinction. In environments lacking mandatory sustainability reporting, the reliance on digital evidence and decision evaluation is not merely complementary but foundational. This contrasts with developed jurisdictions, where digital assurance often supplements existing reporting frameworks (Tiron-Tudor et al., 2021). The comparative implication is that emerging economies may, paradoxically, possess greater flexibility to adopt innovative assurance models unconstrained by entrenched reporting regimes (Guthrie, Manes-Rossi, & Orelli, 2023; IFRS Foundation, 2023).

International guidance from INTOSAI further supports this interpretation. While INTOSAI standards emphasize performance auditing and public value creation, they stop short of prescribing reporting-based sustainability assurance models (INTOSAI, 2019; INTOSAI, 2020). The findings therefore align with global SAI principles while advancing their operationalization through digital means (IFRS Foundation, 2023).

Table 9. Validation of Research Propositions

Proposition	Core Claim	Evidence from Findings	Supporting Literature
P1	Assurance without reports	Digital operational evidence sufficient	Alles (2015); Appelbaum et al. (2020; EFRAG, 2023))
P2	Decision-focused assurance	Early evaluation of sustainability trade-offs	Christensen et al. (2020); Power (2021; GRI, 2021)
P3	Sovereign legitimacy	Mandate-compatible assurance feasible	Scott (2014); Humphrey et al. (2017; UNDP, 2021)
P4	Public value integration	Impact-oriented sustainability evaluation	Bryson et al. (2014); Schaltegger et al. (2021; SEC, 2022))

6.5 Theoretical, Practical, and Social Implications

Table 10. Summarizes Implication of Sovereign Digital Sustainability Assurance

Theoretical Implications

The study advances sustainability assurance theory by decoupling assurance from mandatory reporting and repositioning it as a decision- and impact-centered evaluative function. It extends public value theory into the assurance domain and integrates digital auditing as a constitutive—not auxiliary—element of sustainability governance (Christensen et al., 2020; Alles, 2015). This theoretical integration addresses fragmentation in prior literature and provides a coherent foundation for future research.

Practical Implications

For practitioners and SAIs, the findings demonstrate that sustainability assurance can be operationalized immediately using existing digital infrastructures and mandates. Auditors can leverage system logs, workflows, and operational data to assess sustainability integration without awaiting new reporting regulations (INTOSAI, 2019; Brown-Liburd, Issa, & Lombardi, 2022). This enhances audit relevance and timeliness while reducing dependence on symbolic disclosures (NIST, 2023).

Social Implications

From a societal perspective, decision-centric digital assurance strengthens public accountability by focusing scrutiny on how public resources and authority are exercised. This contributes to improved transparency, trust in public institutions, and alignment of public action with sustainable development objectives (OECD, 2023; World Bank, 2021; NIST, 2024).

Table 10. Implications of Sovereign Digital Sustainability Assurance

Dimension	Traditional Assurance	Sovereign Digital Assurance
Accountability focus	Disclosure transparency	Decision quality and impacts
Audit timing	Retrospective	Continuous / upstream
Institutional fit	Reporting-dependent	Mandate-compatible
Societal value	Symbolic assurance	Substantive public value

6.6 Policy and Professional Recommendations

Based on the findings, several policy and professional recommendations emerge. First, SAIs should formally recognize digital operational data as primary assurance evidence for sustainability evaluation, integrating analytics and process mining into performance audit practices (Alles, 2015; OECD, 2020). Second, sustainability assurance should be embedded within existing audit cycles rather than introduced as a separate reporting-based function.

Third, policymakers should support digital assurance capacity-building within SAIs, focusing on data governance, analytical skills, and interdisciplinary expertise rather than solely on sustainability reporting standards (INTOSAI, 2020). Finally, international standard-setters should acknowledge report-independent assurance models as legitimate pathways for advancing sustainability accountability in diverse institutional contexts (AI4Gov, 2022).

7. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

7.1 Conclusion

This study set out to reconceptualize sustainability assurance in Supreme Audit Institutions (SAIs) by addressing a fundamental institutional and methodological challenge: how sustainability assurance can be meaningfully conducted in public-sector environments where sustainability reporting is not legally mandated and where accountability is primarily institutional rather than market-driven. Drawing on insights from sustainability assurance, public value theory, institutional design, and digital auditing, the study developed and analytically applied a Sovereign Digital Sustainability Assurance Framework (SDSAF).

The core contribution of the study lies in shifting the logic of sustainability assurance away from report-centric verification toward a decision-, evidence-, and impact-oriented evaluative function. The findings demonstrate that sustainability-relevant assurance evidence is widely embedded within public-sector digital systems, including budgeting, procurement, project management, and service delivery platforms. By leveraging this system-embedded evidence, SAIs can conduct sustainability assurance without reliance on formal sustainability reports, thereby overcoming legal, institutional, and practical constraints identified in prior research (Alles, 2015; Appelbaum et al., 2020; Power, 2021).

By positioning sustainability assurance within the mandate-compatible activities of SAIs—such as performance auditing and public value evaluation—the proposed framework advances a sovereign assurance logic that preserves institutional autonomy, legal compatibility, and data governance control (INTOSAI, 2019; Kraemer et al., 2009). This logic is particularly relevant for emerging economies, where digital transformation often outpaces the institutionalization of sustainability reporting frameworks.

The analytical application of the framework to the Egyptian public-sector context demonstrates that the absence of sustainability reporting should not be interpreted as an absence of accountability capacity. On the contrary, digitally enabled public administrations may offer fertile ground for innovative assurance models that are more substantively aligned with governance realities and sustainable development objectives (OECD, 2023; Guthrie et al., 2023).

7.2 Contributions of the Study

The study makes three interrelated contributions. First, it contributes to the sustainability assurance literature by decoupling assurance from mandatory reporting and reconceptualizing it as an evaluative function centered on public decisions and impacts. Second, it extends digital auditing theory by demonstrating how system-embedded evidence can serve as the primary foundation for sustainability assurance rather than merely supporting traditional audit tasks (Vasarhelyi et al., 2015; Christensen et al., 2020).

Third, it advances public-sector accountability theory by integrating public value considerations into assurance design, thereby aligning sustainability evaluation with the core objectives of public governance (Bryson et al., 2014; Zeff, 2016).

7.3 Policy and Professional Implications

From a policy perspective, the findings suggest that governments and standard-setters should reconsider the assumption that sustainability accountability must be built exclusively around reporting mandates. Instead, greater attention should be directed toward enabling SAIs to access, analyze, and interpret digital operational data for sustainability assurance purposes (OECD, 2020; INTOSAI, 2020).

Professionally, the study highlights the need for SAIs to invest in digital audit capabilities, including data analytics, process mining, and interdisciplinary expertise. Such investments can enhance the relevance, timeliness, and societal value of audit work without requiring immediate legislative reform or the introduction of parallel sustainability reporting systems (Brown-Liburd et al., 2022; Cohen et al., 2017; Newell & Frynas, 2007; Zadek, 2007).

7.4 Limitations of the Study

As a design-oriented and analytically grounded study, this research does not provide statistical validation of the proposed framework. The findings are based on analytical generalization rather than empirical representativeness (Yin, 2018; Flyvbjerg, 2006). While this approach is appropriate for theory-building and institutional design, future research may complement it with empirical applications across multiple jurisdictions (Parker, 2020; Abdallah & Ismail, 2017).

7.5 Directions for Future Research

Several avenues for future research emerge from this study. First, empirical studies could examine the implementation of sovereign digital sustainability assurance practices across different SAIs to assess variation in institutional adoption and impact. Second, future research may explore how specific digital tools—such as process mining or explainable AI—can be operationalized within SAI environments while preserving transparency and professional judgment (Davenport & Miller, 2022; Aslam et al., 2021; Yu & van der Laan Smith, 2019).

Third, comparative studies could investigate how sovereign digital assurance models interact with emerging sustainability reporting regulations, such as the EU's Corporate Sustainability Reporting Directive, to understand complementarities and tensions between report-based and evidence-based accountability regimes (European Commission, 2021). Finally, interdisciplinary research integrating accounting, public administration, and information systems perspectives would further enrich the theoretical foundations of sustainability assurance in digitally transformed states (Simnett & Huggins, 2015; De Villiers et al., 2014).

7.6 Final Remarks

In conclusion, this study argues that the future of sustainability assurance in the public sector does not lie solely in expanding reporting obligations, but in reimagining assurance as a sovereign, digital, and decision-centered function. By leveraging digitally embedded evidence and aligning assurance practices with public value objectives, SAIs can play a transformative role in advancing sustainable development and strengthening public accountability in both emerging and developed economies.

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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