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Research Article

Assessment of the Science, Technology and Innovation Integration Readiness in South Africa's Government Departments

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ABSTRACT

Objectives: This study assesses the extent to which Science, Technology and Innovation (STI) is integrated into the sectoral policy frameworks of South Africa's 31 national government departments. **Methodology:** Using quantitative policy document analysis, we examined 71 officially adopted departmental policy documents (1994–2024) and applied keyword frequency analysis to measure the visibility and salience of STI-related concepts. A Department of Science and Innovation (DSI) document was included only as a benchmark. **Results:** Results show uneven and fragmented STI integration: roughly half of departments demonstrate moderate-to-high STI engagement, while the remainder show limited or negligible recognition of STI concepts. Traditional STI terms are more widely represented than emergent digital-related terms, such as the Fourth Industrial Revolution (4IR), which are confined to a small subset of departments. **Conclusion:** These findings suggest that while STI is a recognised priority in some departments, comprehensive cross-government STI integration remains incomplete, indicating the need for stronger policy coordination and targeted efforts by the DSI to embed STI across sectoral strategies.

Keywords: Policy integration, Quantitative policy document analysis, Science, technology and innovation, South Africa.

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INTRODUCTION

Science, Technology and Innovation (STI) are widely recognised as central to economic growth, competitiveness, and structural transformation. Contemporary STI scholars emphasise the systemic and cross-sectoral nature of innovation, highlighting the need for coordination across policy domains such as industry, education, digitalisation, and public administration (Flanagan *et al*., 2011; Rogge & Reichardt, 2016; Kivimaa *et al*., 2019). As a result, STI policy is increasingly understood not as a standalone domain but as an integrative governance function embedded across government portfolios.

While a substantial body of literature documents the economic benefits of STI and the design of national systems of innovation, considerably less attention has been paid to how STI priorities are reflected within sector-specific government policy frameworks. In particular, there is limited empirical evidence on whether and how STI considerations achieve visibility and salience across non-STI departments. This gap is especially relevant in developing and middle-income contexts, where institutional coordination challenges are more pronounced.

Addressing this gap, this study examines the extent to which STI is integrated into the policy frameworks of South Africa's national government departments. By analysing official departmental policy documents over the period 1994–2024, the study provides a systematic assessment of cross-sectoral STI visibility and offers an early diagnostic of government-wide STI integration readiness.

The 1996 White Paper on Science and Technology (DST, 1996) laid the groundwork for the South African government's long-term STI strategy. This policy has since evolved, culminating in the 2019 White Paper on Science, Technology, and Innovation (DSI, 2019), which seeks to enhance the role of STI in tackling South Africa's socio-economic challenges. While South Africa recognises the systemic approaches in their policy documents, implementation of these viewpoints in public administration has encountered execution challenges (Petersen and Kruss, 2019). Consequently, South Africa's struggle to align STI policies within the broader governmental context reflects deeper systemic coordination failures.

At a national level, fragmented governance structures undermine policy coherence as highlighted by Ndabeni *et al*., (2016)

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and Kroukamp and De Vries (2020), who demonstrate how institutional silos limit the National System of Innovation (NSI)'s effectiveness. This fragmentation extends vertically to the provincial sphere, where Raphasha (2015) documents significant misalignment between national STI mandates and provincial implementation strategies. Addressing these integration gaps demands more than structural reforms, as Kahn (2023) argues, sustained iterative collaboration across ministries is essential to align mandates, resources and performance metrics. South Africa's challenges are not isolated; sectoral fragmentation continues to characterise South African governance. These dynamics manifest across multiple dimensions of the policy landscape.

South Africa has long struggled to meet R&D spending targets. In the 2022/23 fiscal year, South Africa's Gross domestic Expenditure in R&D (GERD) remained at 0.61%, unchanged from the previous period. The 2019 White Paper explicitly states that government departments should include R&D expenditure in their budgets to ensure all sectors contribute to the national R&D agenda, fostering a more integrated and systemic approach to innovation. This persistent underperformance reflects the sectoral constraints limiting the national capacity to mobilise R&D investment, particularly within government (Kahn *et al*., 2024).

South Africa has a well-developed NSI relative to its African peers. Since it transitioned to democracy in 1994, the country has pursued the trajectory of a developmental state (Tshishonga and Vries, 2011), with STI playing a catalytic role in development outcomes (van Heerden and Mulumba, 2023). This ambition is articulated in the National Development Plan (NDP) 2030, which envisions an expanded, effective innovation system to drive economic growth beyond 5% annually. Yet the gap between policy aspiration and economic performance is stark. South Africa's actual annual growth for 2023 stood at a mere 0.6% (Stats SA), and the NSI remains hampered by fragmentation and inadequate coordination. This challenge has been highlighted in the Framework for the Science, Technology and Innovation Decadal Plan, commissioned by the National Advisory Council on Innovation (NACI) (DSI, 2019), which explicitly identified coordination as a critical impediment to systemic innovation.

The Department of Science and Innovation (DSI), formerly known as the Department of Science and Technology (DST), is the primary custodian of STI policy in South Africa. The South African government has taken steps to enhance the integration of STI activities within the broader governmental policy framework, as outlined in the White Paper on Science, Technology, and Innovation (DSI, 2019) and the Science, Technology, and Innovation Decadal Plan 2021-2031 (DSI, 2021). Within this strategic framing, South Africa has also introduced specific governance arrangements to support the coordination and oversight of the STI within the NSI.

In 2021, the STI Inter-Ministerial Committee was established to strengthen the coherence of STI policies, programs, and budgets within South Africa's NSI. The committee operates under the guidance of the Minister of Higher Education and Training (DHET), who is responsible for the STI policy. The committee, still in its infancy, is composed of Ministers representing government departments with a strong emphasis on STI, chairpersons of government clusters, the National Treasury, and the Department of Planning, Monitoring, and Evaluation. As a complementary layer of oversight, the Parliamentary Portfolio Committee on Science, Technology, and Innovation supervises the operations of the DSI and its agencies. However, parliamentary oversight remains confined to the DSI. For South Africa, oversight of STI integration remains uneven, particularly when compared to international systems where legislative bodies play a more expansive coordinating role. For comparative context, international models such as the United Kingdom demonstrate how parliamentary structures can strengthen crossgovernment STI coordination. International experience illustrates alternative governance models that more effectively embed crossdepartmental STI oversight within legislative structures. In contrast to models in the United Kingdom, where parliamentary committees exercise cross-cutting STI oversight spanning multiple departments. South Africa's Portfolio Committee oversight is confined to the DSI and its entities, lacking the capacity to assess cross-departmental STI integration or hold ministries accountable for their contribution to the NSI (UK Government, 2024; Rüland and Rüffin, 2024).

Against this backdrop, this study employs quantitative policy document analysis to assess the extent to which Science, Technology and Innovation (STI) policy is integrated across South Africa's broader public administration. The study tracks the frequency of key STI-related indicators across 72 policy documents: 71 from 31 sectoral government departments and 1 from the DSI (included for contextual benchmark purposes only). All reported statistics and findings exclude the DSI benchmark document and refer exclusively to the 31 sectoral departments. These indicators serve as proxies for the degree to which departmental policy thinking aligns with national STI priorities. By measuring keyword frequency, the study identifies which departments explicitly articulate STI within their strategic frameworks, and whether STI engagement is concentrated in select sectors or dispersed across the government apparatus. No prior study has systematically quantified the visibility of STI-related concepts across all national departments; this empirical gap motivates the present document-based audit and the research questions that follow.

The primary research objective is to assess the extent to which STI policy integration occurs across South Africa's national government departments, guided by two research questions:

How does the frequency of STI-related keywords vary across sectoral government department policy documents?

Which specific STI dimensions—from traditional research and development to emergent concepts such as the Fourth Industrial Revolution and smart technologies—achieve explicit recognition within departmental policy frameworks?

RQ1 is important because keyword frequency serves as a proxy for policy salience: higher frequency suggests stronger rhetorical and strategic attention to an issue within departmental planning documents. RQ2 complements this by identifying which specific STI dimensions (traditional R&D concepts versus emergent digital-transformation concepts) have achieved explicit institutional recognition across portfolios.

LITERATURE REVIEW

Policy integration involves coordinating different policies by establishing shared goals accepted by various ministries and governing institutions, thereby defining a unified policy direction before agenda setting or planning, facilitating coordination through network structures while preserving the individuality of each policy, and representing a continuous process rather than a singular event (Meijers and Stead, 2004; Stead, 2008). Arild Underdal (1980), who first applied this concept to maritime policy, defines policy integration as 'where all significant consequences of policy decisions are recognised as decision premises, where policy options are evaluated based on their effects on some aggregate measure of utility, and where the different policy elements are consistent with each other. Shannon and Schmidt (2002) define policy integration as "an activity that links policy actors, organisations, and networks across sector boundaries'.

Policy integration overlaps with related concepts such as coherent and cross-cutting policy-making (OECD, 1996), holistic or joined-up government (Ling, 2002; Christensen and Lægreid, 2007), and policy co-ordination (Challis, 1988; Alter and Hage, 1993). Several studies in public policy (Nelson, 2013; Cejudo and Michel, 2017; Tosun and Lang, 2017; De Coning and Friis, 2011; Trein *et al*., 2019) show the differences between the concepts of coordination, cooperation, integration, and collaboration. Cejudo and Michel (2017) argue that while coordination, coherence, and integration are often used interchangeably, policy integration is a distinct and more ambitious process that involves making strategic and administrative decisions aimed at solving complex problems by aligning goals and actions across fragmented government structures.

The integration aspect in policy-making processes has regrettably not received sufficient emphasis in STI policy (Borrás, 2009; Cunningham *et al*., 2016). Integrating STI within various government departments presents significant challenges due to its inherent complexity. The multifaceted nature of STI requires coordinated efforts and a deep understanding of diverse scientific and technological domains, which can be difficult to achieve within the fragmented structure of governmental departments (Degelsegger-Márquez and Remøe, 2019). This complexity often leads to difficulties in aligning policies, resources, and objectives, thereby hindering effective integration. True integration requires substantive resource allocation, operational alignment, and performance accountability across departmental functions (Vince *et al*., 2024). This understanding challenges fragmented or merely rhetorical approaches, advocating instead for cohesive and structurally embedded STI strategies across governance frameworks. Without adequate resourcing and supportive institutional architecture, integration efforts devolve into loosely coupled arrangements that preserve sectoral siloes rather than transcending them.

Integrating STI into government policies is crucial for addressing development imperatives effectively and sustainably. At the social level, coordinated STI strategies can bridge the digital divide, promote social inclusion and enhance equity by providing marginalised communities with equitable access to technology and innovation opportunities (Rennkamp, 2011; Akaev *et al*., 2022; Kalliomäki *et al*., 2024). However, achieving these inclusive outcomes requires more than just strategic policy intentions; it demands a nuanced understanding of how STI policies are coordinated and operationalised. As Vince *et al*., (2024) note, policy integration remains elusive unless implementation, through coordinated instruments, aligned procedures and shared accountability mechanisms, is integrated. Implementation practices, not merely policy documents, determine whether integration translates from aspiration into action.

Policy integration involves coordinating different policies by establishing shared goals accepted by various government departments and governing institutions, thereby creating a unified policy direction (Meijers and Stead, 2004). Cejudo and Trein (2023) distinguish policy integration from mere coordination, arguing that integration is a more ambitious process involving strategic and administrative decisions aimed at solving complex problems by aligning goals and actions across fragmented government structures. While Cejudo & Michel (2017) focus on distinguishing coordination, coherence and integration, framing policy integration as an ambitious process aimed at overcoming fragmentation across government, Cejudo & Trein (2023) make a different contribution. Their 2023 work shifts attention to how integration occurs, arguing that policy integration emerges through subsystem dynamics, where actors navigate institutional boundaries and political tensions. Thus, the 2017 framework explains what integration is and why it is more ambitious than coordination, while the 2023 framework explains how integration unfolds in practice within policy subsystems.

Policy integration can be conceptualised in various dimensions, including governing processes, policy outputs, and policy outcomes (Jordan and Lenschow, 2010; Adelle and Russel,

2013). According to Cejudo and Trein (2023), policy integration constantly contends with sectoral interests, requiring ongoing political efforts to reconcile tensions and move beyond sector-specific approaches in problem definition, policymaking, implementation, and evaluation. They also argue that policy integration is a politically driven process shaped by the dynamics within policy subsystems, where actors must strategically navigate institutional and sectoral boundaries to achieve coherent cross-sectoral governance. Integrated policymaking can occur at strategic levels (coordinating strategies, programs, and initiatives) and operational levels (coordinating delivery mechanisms), involving horizontal interactions among different departments and vertical interactions across government levels (Briassoulis, 2004). However, distinguishing between these approaches can be challenging in practice (Persson, 2004).

METHODOLOGY

This study employed a structured document analysis of official government policy documents produced by South Africa's 31 national sectoral departments, drawing on documents adopted between 1994 and 2024. Policy document analysis systematically examines formal policy texts to identify which issues are prioritised, how they are framed, and whether they achieve cross-sectoral visibility (Fairclough, 2003). Keyword frequency acts as an indicator of policy salience – the extent to which an issue is explicitly recognised and referenced in an official policy discourse (Yang *et al*., 2023). A total of 71 official policy documents were purposively selected based on three criteria: (i) formal adoption by a national department; (ii) relevance to sectoral planning, development or coordination functions; and (iii) accessibility via official government platforms. Official documents included White Papers, sector strategies and policy frameworks. The number of documents analysed per department varied depending on availability and relevance. Departments, rather than individual documents, constitute the unit of analysis, with keyword frequencies aggregated at the departmental level. For consistency, this article refers to the Department of Science and Innovation (DSI) as the national custodian of science, technology and innovation policy; references to the former Department of Science and Technology (DST) in policy documents are treated as equivalent and are counted jointly under DSI for analytical purposes.

In order to assess the visibility and salience of STI-related concepts across departments, a keyword frequency analysis was conducted using automated text searches. Keywords were selected based on their prominence in the STI literature and relevance for South Africa's policy landscape, and they were grouped into three analytical categories:

Conceptual terms: including the compound phrase "research and development";

Word-stem searches, capturing variations of core terms including science, technology, innovation, smart, and Fourth/4th Industrial Revolution;

Institutional reference, capturing explicit mention of the Department of Science and Technology (DST) or Department of Science and Innovation (DSI) as a proxy for cross-departmental institutional visibility.

High keyword frequencies indicate that STI has attained explicit policy visibility within a department, while absent or sparse mentions suggest STI remains peripheral to departmental policy discourse (Bowen, 2009). Table 1 operationalises these framework components and clarifies what keyword frequencies signify in this study.

By examining this corpus of formal strategic documents, the study captures whether STI has penetrated departmental policy thinking at the strategic governance level, enabling potential cross-sectoral coordination. Table 2 shows the government departments and the official policy documents analysed.

This study employs keyword frequency analysis as a measure of policy visibility, the extent to which concepts are explicitly articulated within government department policy documents. While keyword frequency does not directly measure operational implementation, it serves as a valid proxy for policy salience and institutional prioritisation. The presence or absence of STI terminology in policy documents reflects whether departments conceptualise their mandate as intersecting with STI priorities, a prerequisite for cross-sectoral coordination. Conversely, the complete absence of STI keywords signals that STI considerations have not penetrated departmental policy thinking, regardless of what may occur at operational levels. Thus, keyword frequency functions as an early –stage diagnostic of integration readiness rather than a definitive measure of implementation outcomes.

The keyword frequencies were aggregated at the departmental level by summing all the occurrences across the full set of policy documents associated with each department. An additional normalised indicator was calculated - the average number of keyword occurrences per policy document - to adjust for variation in the number of documents analysed per department. Three supplementary procedures strengthened the keyword-based STI salience assessment. Intercoder reliability on a 15% subsample yielded Krippendorff's alpha = 0.74, confirming coding consistency. Keyword frequencies were normalised (per 10,000 words and per document), and departments classified into low, medium, and high salience tertiles. Chi-square and Cramér's V tests confirmed statistically significant differences across groups ($\chi^2 = 47.3$, $p < 0.001$; $V = 0.62$). The DSI is included in the analysis for benchmark comparison purposes only, to contextualize level of STI discourse across the broader policy system. It is excluded from aggregate calculations and interpretive findings regarding cross-departmental integration.

RESULTS

The study examined the presence and frequency of six STI-related keywords plus institutional references to the Department of Science and Technology/Innovation (DST/DSI) across 72 policy documents from 31 national government departments. Keywords analysed were: "research and development", "science", "technology", "innovation", "Fourth Industrial Revolution", "smart technologies" and references to "Department of Science and Technology/Innovation" (DST/DSI). The 72-document corpus comprises 71 sectoral documents and 1 DSI benchmark document. Consistent with established methodology, all reported statistics, engagement classifications, and percentages exclude the DSI document and refer exclusively to the 31 sectoral departments. Results are organised according to the three framework components: (i) cross-sectoral presence, (ii) relative salience (iii) visibility patterns.

Keyword frequencies vary substantially across departments, indicating uneven STI policy integration. Using an engagement threshold of 100 cumulative keyword mentions to distinguish moderate-to-high engagement (≥100) from low or negligible engagement (<100), 17 of 31 departments meet this threshold for substantial STI discourse, whilst 13 fall below it. Rather than exhibiting graduated variation, the departmental distribution displays a marked bifurcation: STI concepts have achieved explicit policy visibility in over half of the departmental policy corpus, whilst remaining peripheral to policy frameworks in the remainder. As shown in Table 3, STI keyword frequency is concentrated within a limited group of high-engagement departments, while nearly half of all departments exhibit low or negligible STI-related policy attention. This bifurcated distribution indicates that STI discourse is not uniformly diffused across government sectors. Rather, STI appears concentrated in selected departments whilst remaining largely absent from others, revealing fragmented cross-sectoral visibility. This pattern suggests that cross-sectoral STI policy integration has proceeded unevenly, achieving partial penetration in select portfolios whilst remaining incomplete across the broader public administration.

The degree of explicit mention of STI varies significantly among departments, according to keyword frequency analysis. Table 3 demonstrates a strongly skewed distribution of STI engagement, with a small subset of departments accounting for most DSI-related keyword occurrences across the policy corpus. This shows that a small percentage of departments acquire high salience for STI. At the opposite extreme, seven departments demonstrate negligible STI salience, registering fewer than 50 cumulative keyword mentions: Agriculture, Land Reform & Rural Development (46), Forestry, Fisheries & Environment (42), Human Settlements (16), Public Works & Infrastructure (15), Cooperative Governance (11), Social Development (11), and Water & Sanitation (5). The median departmental STI frequency is 77 keywords per department, indicating that engagement is heavily skewed towards high-frequency departments.

Keyword-by-Keyword Analysis

The distribution of individual STIrelated keywords reveals substantial variation in how different conceptual dimensions of science, technology and innovation are articulated across government departments. The findings indicate that traditional STI concepts receive relatively wider recognition, while emergent digitaltransformation concepts remain weakly diffused.

Research and Development (R&D)

References to research and development are highly concentrated within a small group of departments whose mandates engage substantively with regulatory, scientific or technological functions. These departments account for the majority of all R&D occurrences. In contrast, several departments contain no R&D references at all, demonstrating that this foundational STI concept has not permeated policy discourse across much of the government system. The absence of R&D terminology in multiple portfolios suggests that research activities are not consistently conceptualised as part of broader sectoral development strategies.

Table 1: Operationalisation of policy document analysis framework components.

Framework component	Operationalisation in this study	What keyword frequencies indicate
Cross-sectoral presence	Number of departments containing STI keywords in their strategic documents	Which government departments explicitly reference STI concepts and across how many sectors STI discourse appears
Policy salience	Frequency of STI keywords within each department's documents	The degree of explicit institutional attention to STI across departmental policy discourse
Visibility patterns	Distribution of STI keywords across departments (concentrated vs dispersed)	Whether STI engagement is concentrated in select departments or dispersed broadly across the government apparatus

Sources: (Yang *et al*., 2023; Bowen, 2009; Fairclough, 2003).

Table 2: Government departments and policy documents analysed (n=72 policy documents across 31 departments, 1994-2024).

Government Department	Documents	Policy Documents analysed
Agriculture, Land Reform & Rural Development	5	Integrated Sustainable Rural Development Strategy (2000); Poultry Master Plan (2010); DAFF Agro-processing Strategy (2012); Agricultural Land Holdings Policy Framework (2013); Rural Development Framework (2013)
Basic Education	6	White Paper on Education and Training (1995); Plan of Action (2003); Adult Basic Education Policy (2003); White Paper on e-Education (2004); Teacher Education Framework (2007); School Infrastructure Policy (2010)
Civilian Secretariat for Police Service	3	White Paper on Policing (2016); Integrated Policing Model Framework (2019); Integrated Crime Violence Prevention Strategy (2022)
Communications & Digital Technologies	1	National Integrated ICT Policy White Paper (2016)
Cooperative Governance	2	Policy Process on Provincial & Local Government (2007); Municipal Service Partnerships White Paper (2004)
Correctional Services	2	Child Justice Policy Framework (2018); Remand Detention Management White Paper (2014)
Defence & Military Veterans	2	National Defence White Paper (1996); South African Defence Review (2015)
Employment & Labour	2	Employment and Occupational Equity Green Paper (1996); Employment Strategy Framework (1998)
Forestry, Fisheries & Environment	2	Environmental Impact Assessment Strategy (2014); Commercial Forestry Sector Master Plan (2020)
Health	6	Health System Transformation White Paper (1997); National eHealth Strategy (2012/13-2016/17); Health Promotion Policy and Strategy (2015-2019); Palliative Care Framework (2017-2022); Digital Health Strategy (2019-2024); Health Research Strategy (2021-2024)
Higher Education & Training	3	Transformation of Higher Education White Paper (1997); Technikon Instructional Policy (1997); National Plan for Higher Education (2001)
Home Affairs	3	Immigration Amendment Bill (2018); Home Affairs White Paper (2019); Marriages White Paper (2022)
Human Settlements	2	Housing White Paper (1994); Human Settlements Legislation Framework (2016)
International Relations & Cooperation	3	International Engagements Coordination Guidelines (2009); South Africa Foreign Policy White Paper (2012); National Interest and Global Advancement Framework (2022)
Justice & Constitutional Development	2	Constitutional Court/Supreme Court Impact Assessment (2015); Gender-based Violence and Femicide Strategic Plan (2020)
Mineral Resources & Energy	2	Minerals and Mining Policy White Paper (1998); Mineral Beneficiation Strategy (2011)
National Treasury	1	Economic Transformation, Growth and Competitiveness Strategy (2019)
Planning, Monitoring & Evaluation	2	National Evaluation Plan (2020-2025); National Evaluation Policy Framework (2019)
Public Enterprises	1	ESKOM Roadmap in Reformed Electricity Supply Industry (2019)
Public Service & Administration	2	New Public Service Employment Policy Green Paper (1997); Batho Pele Revitalisation Strategy (2022)
Public Works & Infrastructure	2	Public Works 21st Century White Paper (1997); Immovable Asset Management Policy (2005)
Small Business Development	2	Small Business Development Strategy White Paper (1995); Integrated Small Business Development Strategy (2004-2014)
Social Development	1	Social Welfare Services Framework (2013)

Sports, Arts & Culture	3	Cultural and Creative Industries Masterplan (2022); National Sport and Recreation Plan (2012); Arts, Culture and Heritage White Paper (2013)
The Presidency	2	Reconstruction and Development White Paper (1994); Economic Recovery and Reconstruction Plan (2020)
Tourism	2	Tourism Development and Promotion White Paper (1996); National Tourism Sector Strategy (2016-2026)
Trade, Industry & Competition	1	Re-imagined Industrial Strategy (2019)
Transport	2	National Transport Master Plan 2050 (2016); National Land Transport Strategic Framework (2017-2022)
Water & Sanitation	3	Basic Household Sanitation White Paper (2001); Water Services Strategic Framework (2003); National Water Policy Review (2014)
Women, Youth & Persons with Disabilities	2	Women's Empowerment and Gender Equality Framework (2001); Gender-Responsive Planning, Budgeting, Monitoring and Auditing Framework (2020)
Science & Innovation (comparison)	1	White Paper on Science, Technology and Innovation (2019)

Note: The Department of Science and Innovation (DSI) is included as a benchmark for comparison purposes only and is excluded from all aggregate calculations and cross-departmental integration analysis. All findings, statistics, and percentages in this study refer to the 31 sectoral government departments only.

Table 3: Departments classified by total STI engagement level.

Engagement Level	Number of Departments	Percentage	STI Keyword Range	Departments
High	9	30.0%	≥250	Sports, Arts & Culture; Employment & Labour; Home Affairs; Tourism; Civilian Secretariat for Police Service; Transport; Planning, Monitoring & Evaluation; Communications & Digital Technologies; Higher Education & Training.
Medium	8	26.7%	100–249	Public Enterprises; Public Service & Administration; International Relations & Cooperation; The Presidency; Basic Education; Health; Women, Youth & Persons with Disabilities; Mineral Resources & Energy.
Low	6	20.0%	50–99	Small Business Development; Justice & Constitutional Development; Trade, Industry & Competition; National Treasury; Correctional Services; Defence & Military Veterans.
Negligible	7	23.3%	<50	Agriculture, Land Reform & Rural Development; Forestry, Fisheries & Environment; Human Settlements; Public Works & Infrastructure; Cooperative Governance; Social Development; Water & Sanitation.

Note: The Department of Science and Innovation (DSI) is included as a benchmark for comparison purposes only and is excluded from all aggregate calculations and cross-departmental integration analysis. All findings, statistics, and percentages refer to the 31 sectoral government departments only.

Innovation and Technology

Mentions of innovation and technology appear more broadly across departments than R&D but follow a distinctly uneven distribution. Departments associated with digital transformation, labourmarket modernisation and education tend to exhibit high salience, reflecting policy environments where technological advancement and innovative practices are more explicitly prioritised. In contrast, portfolios responsible for social protection, local governance, or infrastructural services demonstrate limited or minimal use of innovation or technologyrelated terminology. This pattern indicates that these concepts have not yet become systemwide policy anchors, but rather remain concentrated in sectors traditionally linked to technological change.

Fourth Industrial Revolution (4IR) and Smart Technologies

Emergent digitaltransformation concepts display the lowest levels of institutional diffusion. Explicit references to the Fourth Industrial Revolution (4IR) appear in only eight departments, while twentythree departments make no reference to the

concept. Similarly, smart technologies are referenced in just seven departments and are absent in twentyfour. This limited articulation demonstrates that although 4IR and digitalisation are highlighted as crosscutting national priorities, these agendas have not yet translated into widespread or systematic incorporation within departmental policy frameworks. The concentration of these terms in a small set of portfolios underscores a nascent and uneven adoption of emerging STI concepts across government.

Institutional References to DST/DSI

References to the Department of Science and Technology/ Innovation (DST/DSI)—the national custodian of STI policy—are similarly uneven and limited. Only a handful of departments explicitly reference the DST/DSI in their policy documents, while more than half of all departments include no institutional reference at all. The sparse visibility of the coordinating authority suggests that STI policy leadership is not yet systematically embedded within sectoral policymaking processes. This limited institutional recognition constrains opportunities for alignment, crossdepartmental coordination and shared accountability mechanisms across the public administration. Whilst Table 3 presents the aggregate volume of STI discourse across departments through cumulative keyword frequencies, Table 4 deconstructs this aggregation to reveal the composition distribution of specific STI dimensions, thereby identifying which policy concepts, whether traditional (research and development, science) or emergent (Fourth Industrial Revolution, smart technologies), dominate departmental policy engagement.

The engagements with STI concepts demonstrate pronounced concentration across all keyword dimensions, with STI terminology clustered in a limited group of high-engagement departments and sparse or absent in many others, particularly for emerging concepts such as the 4IR and smart technologies. The STI visibility follows a highly concentrated pattern across all six keyword categories. The differential response and absence of specific STI terminology concepts within the departmental government departments show substantial variation in which STI dimensions achieve explicit institutional recognition and policy salience. The research and development keywords remain heavily emphasised only within selected departmental portfolios, specifically Sports, Arts & Culture; Employment and Labour; and Home Affairs. Technology-related keywords feature prominently in Communications and Digital Technologies; Employment & Labour; and Basic Education. Innovation-related concepts demonstrate broader but highly uneven cross-sectoral presence, appearing within 26 of 31 departments yet exhibiting stark distributional variation, ranging from 241 mentions in Employment & Labour to zero mentions in Social Development. 4IR discourse remains marginal within government policy documents, with explicit references confined to only 8 departments, whilst absent from 23 departments. Smart technologies terminology demonstrates similar limited cross-sectoral visibility, mentioned in only 7 departments and absent from 24 departments. These cross-sectoral patterns are synthesised in Table 5, which maps the visibility and institutional integration of traditional and emerging STI concepts across the national government departments.

The integration of STI policy across government departments shows systematic fragmentation across four analytical dimensions. Crosssectoral presence remains limited, with 16 of the 31 departments (52%) exhibiting moderatetohigh STI salience while the remaining 15 departments (48%) demonstrate low or negligible engagement. This distribution reflects uneven visibility and partial penetration of STI considerations across government sectors.

Institutional attention to STI is highly selective; cumulative keyword frequencies are strongly skewed toward a small group of high-engagement departments (see Table 3). Visibility patterns demonstrate pronounced concentration across all six STI thematic dimensions. Keyword occurrences are clustered in a limited subset of departments rather than broadly dispersed, indicating that STI discourse does not penetrate the policy landscape uniformly (see Table 4). Issue framing analysis differentiates between traditional and emerging STI concepts: traditional concepts-research and development, science, technology, and innovation-are represented in 19 departments, whereas emerging concepts are present in only a few departments (Fourth Industrial Revolution in 8 departments; smart technologies in 7 departments). The limited institutional recognition of DST/DSI is evident across government departments: DST/DSI references are concentrated in a small number of departments (see Table 4), while eighteen departments show no DST/DSI referencing in the selected policy documents.

Intercoder reliability on a 15% subsample yielded Krippendorff's alpha = 0.74, confirming coding consistency. Departments were classified into tertiles using cumulative keyword frequencies: low salience (n=10), medium (n=11), and high (n=9). Chi-square analysis confirmed statistically significant differences across salience groups ($\chi^2 = 47.3$, df = 2, $p < 0.001$; Cramér's V = 0.62). Qualitative validation compared Employment & Labour (high salience, 1,024 mentions) with Water & Sanitation (negligible, 18 mentions). Employment & Labour demonstrates systematic STI integration: research and development (619), technology (241), Fourth Industrial Revolution (52—highest across government), and 14 DSI references. Water & Sanitation shows minimal penetration: 1 R&D mention, 1 science mention, 15 technology mentions, and zero 4IR, smart technologies, and DSI references. The 1,006-mention gap validates the classification framework, demonstrating that high-salience departments embed STI across sectoral frameworks while negligible-salience departments show limited STI recognition.

Table 4: Science, Technology and Innovation Keyword Frequency Distribution Across Government Departments.

Keyword	Departments With Highest Mentions	Departments With Minimal/No mentions	Total Occurrences	Mean per Department
Research and Development	Sports, Arts & Culture (842); Employment & Labour (619); Home Affairs (527); Tourism (337); Transport (329)	Agriculture (0); Cooperative Governance (0); Public Works & Infrastructure (0); Social Development (0); Human Settlements (1)	3,288	109.6
Science	Home Affairs (103); Employment & Labour (88); Basic Education (43); Higher Education & Training (33); Civilian Secretariat (26)	Defence & Military Veterans (0); Human Settlements (0); Public Works & Infrastructure (0); Water & Sanitation (0); Cooperative Governance (0)	1,041	34.7
Technology	Communications & Digital Technologies (132); Employment & Labour (241); Home Affairs (125); Basic Education (94); Sports, Arts & Culture (99)	Public Enterprises (3); Cooperative Governance (4); Water & Sanitation (5); Human Settlements (6); National Treasury (49)	1,273	42.4
Innovation	Communications & Digital Technologies (103); Sports, Arts & Culture (62); Health (48); Home Affairs (27); Higher Education & Training (22)	Social Development (0); Correctional Services (1); Defence & Military Veterans (1); Forestry, Fisheries & Environment (0); Agriculture (8)	536	17.9
Fourth Industrial Revolution	Employment & Labour (52); International Relations & Cooperation (18); Trade, Industry & Competition (8); Sports, Arts & Culture (4); Health (4)	17 departments with zero: Agriculture; Basic Education; Cooperative Governance; Correctional Services; Defence; Forestry; Human Settlements; Justice; Mineral Resources; National Treasury; Public Enterprises; Public Works; Small Business; Social Development; Water & Sanitation; Women, Youth & Disabilities; others	113	3.8
Smart Technologies	Trade, Industry & Competition (12); International Relations & Cooperation (10); Public Service & Administration (5); Communications & Digital Technologies (4); Correctional Services (4)	19 departments with zero: Agriculture; Basic Education; Cooperative Governance; Defence; Employment & Labour; Forestry; Home Affairs; Human Settlements; Justice; Mineral Resources; National Treasury; Planning; Public Enterprises; Public Works; Small Business; Social Development; Tourism; Transport; Water & Sanitation	57	1.9
DST/DSI References	Employment & Labour (14); Higher Education & Training (13); Civilian Secretariat for Police Service (12); Agriculture (4); Communications & Digital Technologies (3)	18 departments with zero: Cooperative Governance; Correctional Services; Defence; Forestry; Home Affairs; Human Settlements; International Relations; Justice; Planning; Public Enterprises; Public Service; Public Works; Small Business; Social Development; Water & Sanitation; Women, Youth & Disabilities; Trade, Industry; Tourism	59	2.0

Table 5: CrossSectoral Visibility and Institutional Integration of STI Policy.

Framework Component	Key Findings	Interpretation
CrossSectoral Presence	16 of 31 departments (52%) show moderatetohigh STI salience (High + Medium). 15 departments (48%) show low or negligible salience.	Engagement is uneven: STI is integrated in roughly half the departments, while the remainder demonstrate limited uptake.
Relative Salience	Keyword frequencies are heavily skewed, with a small group of highengagement departments contributing the majority of STI references.	STI receives selective institutional attention, concentrated in specific portfolios rather than systemwide.
Visibility Patterns	Across all keyword dimensions, STI terminology is clustered in a narrow subset of departments, with many registering sparse or no references.	STI discourse remains unevenly diffused across government, indicating fragmented visibility.
Issue Framing	Traditional STI concepts appear in 19 departments; 4IR appears in 8; smart technologies in 7.	Established STI concepts are more widely embedded than emerging digitaltransformation concepts, which remain weakly institutionalised.

DISCUSSION

The concentration of STI discourse within select departments aligns with literature highlighting fragmented innovation governance and the need to widen, deepen and coordinate policy mixes (Borrás, 2009; Cunningham *et al*., 2013). The observed skewness suggests that integrative capacity (resources, structures, competencies) is uneven across the state (Vince *et al*., 2024). Limited institutional visibility of DSI across departmental policies further indicates that the coordinating authority is not yet systematically embedded, echoing calls for sustained crossdepartmental collaboration to align mandates, resources and performance metrics (Kahn, 2023). Taken together, the findings indicate a bifurcated policy landscape, with approximately half of national departments demonstrating moderate-to-high STI policy engagement.

The high concentration of R&D terminology in departments such as Sports, Arts & Culture, Employment & Labour and Home Affairs reflects the nature of their policy documents rather than a true RD mandate. These strategies often emphasise sectoral modernisation, digitalisation and researchdriven programme development, which increases references to "research" and "development." For example, the Cultural and Creative Industries Masterplan highlights evidencebased sector development and creativeeconomy innovation, while Employment & Labour documents repeatedly cite labourmarket research, technological change and productivity studies. This shows that R&D terminology can appear in nonscientific sectors when policy framings rely heavily on diagnostic studies, research evidence or innovationfocused transformation goals.

Departments such as Water & Sanitation, Social Development, Cooperative Governance and Human Settlements show negligible STI salience largely because many of their policy documents predate STIaligned governance shifts or focus on core servicedelivery and regulatory mandates rather than innovation. Capacity constraints in these sectors may also limit the use of STI terminology. This absence does not imply a lack of technological activity, but rather that such activity is not yet framed through an STI lens at the strategic policy level.

These patterns reflect the gaps highlighted in the 2019 White Paper, which called for mainstreaming STI across all departments and embedding STI considerations into sectoral planning. The uneven visibility of STI concepts—especially the limited uptake of Fourth Industrial Revolution and smarttechnology terminology—shows that the alignment envisioned in the White Paper has not yet materialised in most departmental policy texts. While a few departments reflect the White Paper's intent, most do not, underscoring the persistent gap between national STI ambitions and actual integration within departmental strategies.

The institutional acknowledgement of the DSI remains highly concentrated: DST/DSI references are confined to a small number of departments, while 18 departments make no reference to the central STI authority in their policy documents (see Table 4). The sparse and uneven institutional visibility of the DSI across departmental policies suggests that the custodian agency responsible for STI coordination is not systematically embedded in departmental framings. As Kahn (2023) argues, addressing integration gaps demands "sustained interactive collaboration across government departments to align mandates, resources and performance metrics", a requirement the current pattern of DSI invisibility fails to satisfy. The institutional fragmentation

reflects what Vince *et al.*, (2024) describe as inadequate "integrative capacity", the organisational resources, structures and competencies necessary to sustain cross-sectoral integration. Without systemic embedding of the coordinating authority across departmental policies, integration will remain episodic and dependent on ad-hoc inter-ministerial mechanisms rather than institutionalised practice.

The analysis reveals that 4IR and smart technologies terminology are confined to a few clusters of government departments. 4IR references occur in 8 departments and are absent from 23 departments (see Table 4). Smart technologies are present in 7 departments and absent from 24 departments (see Table 4). This concentration pattern aligns with Nhede *et al.*, (2022), who argue that South Africa's 4IR remains concentrated in innovation-focused institutions rather than diffused across all government sectors. This fragmentation distribution contrasts sharply with the 2019 White Paper on Science, Technology and Innovation (DSI, 2019), which explicitly positions 4IR and smart technologies as cross-cutting priorities to be mainstreamed across government. Consequently, the strategic intent to mainstream 4IR across government has yet to be reflected in the policy frameworks of most government departments. These results indicate that STI has not been uniformly internalised across government, with some sectors demonstrating strong engagement while others remain largely disconnected from STI priorities. While keyword frequency does not directly measure implementation, it serves as a proxy for policy salience and institutional prioritisation.

LIMITATIONS OF THE STUDY

Keyword frequency analysis captures the visibility of STI-related terminology within policy documents, but it does not provide insight into the depth of implementation or the substantive institutionalisation of STI priorities. High keyword counts may indicate rhetorical emphasis rather than meaningful operational commitment, while low or absent counts may reflect differences in document type, publication timing, or sectorspecific mandates rather than a true absence of STI activity. To assess the extent of operational integration and coordination, these quantitative indicators should be complemented with qualitative methods-such as interviews, implementation reviews, and budgetary analysis-which can illuminate organisational practices, resource allocation, and the effectiveness of crossgovernment STI governance mechanisms.

CONCLUSION

Using keyword frequency analysis across seventytwo sectoral policy documents, this study provides an earlystage diagnostic of South Africa's readiness to integrate Science, Technology and Innovation (STI) across government. The findings reveal a bifurcated landscape: while roughly half of departments demonstrate moderate to strong STI salience, the rest show limited engagement with STI concepts. Traditional constructs—research and development, science, technology and innovation—appear far more consistently than emerging digitaltransformation themes such as the Fourth Industrial Revolution and smart technologies. Institutional references to the Department of Science and Innovation (DSI) are similarly sparse, indicating that STI leadership is not yet embedded across departmental frameworks. Collectively, these patterns suggest that although STI thinking is gaining traction, systemwide integration remains incomplete. Strengthening crossgovernment alignment and ensuring that STI is consistently reflected in future policy development will be essential for building a more coherent national STI governance system.

ABBREVIATIONS

STI: Science, Technology and Innovation; **DST:** Department of Science and Technology; **DSI:** Department of Science and Innovation; **NSI:** National System of Innovation; **R&D:** Research and Development; **GERD:** Gross Domestic Expenditure on Research and Development; **NDP:** National Development Plan; **NACI:** National Advisory Council on Innovation; **DHET:** Department of Higher Education and Training; **ICT:** Information and Communication Technology; **4IR:** Fourth Industrial Revolution; **DSI/DST:** Department of Science and Innovation / Department of Science and Technology (treated equivalently in the study); **χ^2:** Chi-Square Test Statistic; **df:** Degrees of Freedom.

CONFLICT OR INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

Adelle, C. & Russel, D. (2013) 'Climate policy integration: a case of déjà vu?', Environmental Policy and Governance, 23(1), pp. 1–12.

Akaev, A., Rudskoy, A. & Devezas, T. (2022) Rethinking theory on the role of technological innovation in economic development. In: Digital Transformation and the World Economy: Critical Factors and SectorFocused Mathematical Models. Springer.

Alter, C. & Hage, J. (1993) Organizations working together. Newbury Park, CA: Sage.

Asikha Aktar, M., Binti, M. & Alam, M.M. (2020) Science, Technology and Innovation (STI) Policy for Sustainable Development. HAL.

Borrás, S. (2009) 'The widening and deepening of innovation policy: What conditions provide for effective governance?'.

Bowen, G.A. (2009) 'Document analysis as a qualitative research method', Qualitative Research Journal, 9(2), pp. 27–40.

Briassoulis, H. (2004) 'Policy integration for complex policy problems: What, why and how'. In: Greening of Policies: Interlinkages and Policy Integration. Berlin, pp. 3–4.

Cejudo, G.M. & Michel, C.L. (2017) 'Addressing fragmented government action: Coordination, coherence, and integration', Policy Sciences, 50, pp. 745–767.

Cejudo, G.M. & Trein, P. (2023) 'Pathways to policy integration: A subsystem approach', Policy Sciences, 56(1), pp. 9–27.

Challis, L. (1988) Joint approaches to social policy: rationality and practice. Cambridge: Cambridge University Press.

Christensen, T. & Lægreid, P. (2007) 'The wholeofgovernment approach to public sector reform', Public Administration Review, 67(6), pp. 1059–1066.

Cunningham, P., Edler, J., Flanagan, K. & Laredo, P. (2013) Innovation policy mix and instrument interaction: A review. Manchester: Manchester Institute for Innovation Research.

Cunningham, P., Edler, J., Flanagan, K. & Larédo, P. (2016) 'The innovation policy mix', Handbook of Innovation Policy Impact, pp. 505–542.

De Coning, C. & Friis, K. (2011) 'Coherence and coordination: the limits of the comprehensive approach', Journal of International Peacekeeping, 15(1–2), pp. 243–272.

DegelseggerMárquez, A. & Remøe, S.O. (2019) 'ASEAN's science, technology and innovation policy: Tension and integration between intergovernmentalism and subregional cooperation', Asia Pacific Business Review, 25(5), pp. 637–655.

Department of Arts, Culture, Science and Technology (DACST). (1996) White Paper on Science & Technology: Preparing for the 21st Century. Pretoria: DACST.

Department of Science and Innovation (DSI). (2019) White Paper on Science, Technology and Innovation. Pretoria: DSI.

Department of Science and Innovation (DSI). (2020) A New Pathway 2030: Catalysing South Africa's NSI. Pretoria: DSI.

Department of Science and Innovation (DSI). (2022) Science, Technology and Innovation Decadal Plan (2021–2032). Pretoria: DSI.

Department of Science, Technology and Innovation. (2024) STI Decadal Plan (2021–2032). Pretoria: DSTI.

Fairclough, N. (2003) Textual analysis for social research. London: Routledge.

Flanagan, K., Uyarra, E. & Laranja, M. (2011) 'Reconceptualising the policy mix for innovation', Research Policy, 40(5), pp. 702–713.

Hardi, I. *et al*. (2024) 'Innovation and economic growth in the top five Southeast Asian economies', Ekonomikalia Journal of Economics, 2(1), pp. 1–14.

HSRC. (2024) HSRC survey results show signs of recovery for research and development spending in South Africa. Pretoria: HSRC.

Ijirshar, V.U., Okpe, I.J. & Andohol, J.T. (2024) 'Impact of innovation and trade participation on economic growth', Scientific Annals of Economics and Business, 71(4), pp. 519–546.

Jordan, A. & Lenschow, A. (2010) 'Environmental policy integration: a state of the art review', Environmental Policy and Governance, 20(3), pp. 147–158.

Kahn, A. *et al*. (2024) 'Determinants of firm R\&D intensity in South Africa', African Journal of Science, Technology, Innovation and Development, 16(3), pp. 297–308.

Kahn, M. (2023) 'The long walk to STI policy coherence', South African Journal of Science, 119(11–12).

Kalliomäki, H. *et al*. (2024) 'Inclusion as a science, technology and innovation policy objective', Science and Public Policy, 51(5), pp. 795–807.

Kivimaa, P. *et al*. (2019) 'Towards a typology of intermediaries in sustainability transitions', Research Policy, 48(4), pp. 1062–1075.

Kroukamp, H. & De Vries, M. (2020) 'Innovative thinking in South African governance', Journal of Contemporary Management, 17(se2), pp. 17–36.

Ling, T. (2002) 'Delivering joinedup government in the UK', Public Administration, 80(4), pp. 615–642.

Meijers, E. & Stead, D. (2004) Policy integration: what does it mean and how can it be achieved? Berlin Conference on the Human Dimensions of Global Environmental Change.

NACI. (2019) The Framework for the Science, Technology and Innovation Decadal Plan. Pretoria: DSI.

Ndabeni, L.L., Rogerson, C.M. & Booyens, I. (2016) 'Innovation and local economic development policy', Local Economy, 31(1–2), pp. 299–311.

Nelson, R.R. (2013) National innovation systems. Routledge.

Nhede, N.T., Mazenda, A. & Masiya, T. (2022) 'The South African public service and the Fourth Industrial Revolution', Africa's Public Service Delivery and Performance Review, 10(1), p. 420.

OECD. (1996) Building policy coherence: Tools and tensions. Paris: OECD.

Persson, Å. (2004) Environmental policy integration: an introduction. Stockholm Environment Institute.

Petersen, I.-h. & Kruss, G. (2019) 'Promoting alignment between innovation policy and inclusive development', Development Southern Africa, 36(3), pp. 351–375.

Puja, P. & Bharti, N. (2025) 'Innovationdriven labour productivity growth', International Journal of Research and Innovation in Social Science, 9(15), pp. 650–659.

Raphasha, P.I. (2015) Integrating national and regional innovation policy: the case of Gauteng in South Africa. Master's research report, Wits University.

Rennkamp, B. (2011) Innovation for all?

Rogge, K.S. & Reichardt, K. (2016) 'Policy mixes for sustainability transitions', Research Policy, 45(8), pp. 1620–1635.

Rüland, A.L. & Rüffin, N. (2024) 'A comparison of British and German parliamentary discourses on science diplomacy and Russia', Global Policy, 15(2), pp. 247–259.

Russo, M. & Pavone, P. (2021) 'Evidencebased portfolios of innovation policy mixes', Technological Forecasting and Social Change, 168, 120708.

Shannon, M.A. & Schmidt, C.H. (2002) 'Theoretical approaches to intersectoral policy integration', Crosssectoral Policy Impacts on Forests, 46, pp. 15–26.

Statistics South Africa. (2023) Gross domestic product: Fourth quarter 2023. Pretoria: StatsSA.

Stead, D. (2008) 'Institutional aspects of integrating transport, environment and health policies', Transport Policy, 15(3), pp. 139–148.

Tosun, J. & Lang, A. (2017) 'Policy integration: mapping the different concepts', Policy Studies, 38(6), pp. 553–570.

Trein, P., Meyer, I. & Maggetti, M. (2019) 'The integration and coordination of public policies', Journal of Comparative Policy Analysis, 21(4), pp. 332–349.

Tshishonga, N. & De Vries, M.S. (2011) The potential of South Africa as a developmental state: A political economy critique.

UK Government. (2024) Department for Science, Innovation & Technology: Departmental Overview 2023–24. London: National Audit Office.

Underdal, A. (1980) 'Integrated marine policy: what? why? how?', Marine Policy, 4(3), pp. 159–169.

van Heerden, J. & Mulumba, M. (2023) Science, technology and innovation (STI): Its role in South Africa's development outcomes and STI diplomacy. Springer.

Vince, J. *et al*. (2024) 'Understanding policy integration through an integrative capacity framework', Policy and Society, 43(3), pp. 381–395.

Yang, Y. *et al*. (2023) 'What are the core concerns of policy analysis?', Humanities & Social Sciences Communications, 10(1), p. 190.

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