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AI and Blockchain Adoption in E-Government 3.0: A Systematic Review and Conceptual Framework

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Abstract. This study presents a systematic review of the adoption of Artificial Intelligence (AI) and Blockchain technologies in E-Government 3.0 within developing countries, based on 99 reviewed studies published between 2020 and 2025. Using the PRISMA 2020 protocol, the review synthesizes existing literature to identify key barriers, opportunities, and emerging governance patterns. The findings suggest that while AI appears to enhance decision-making capabilities, and blockchain is associated with enhanced transparency and data integrity, their successful adoption appears to be constrained by institutional capacity, regulatory frameworks, organizational readiness, and digital trust. The results further indicate that technological factors alone are insufficient without alignment with governance structures and policy environments. Based on the synthesis, this study proposes the SIF-G3.0 conceptual framework, which integrates technological, institutional, regulatory, and trust dimensions as a conceptual model for understanding digital government transformation. The proposed SIF-G3.0 framework remains conceptual and has not yet been empirically validated. The evidence base included heterogeneous sources, including empirical, conceptual, bibliometric, and systematic review studies. The study also highlights critical research gaps and provides directions for future research in hybrid intelligent governance systems.

Keywords: systematic literature review, e-government 3.0, artificial intelligence, blockchain, digital governance, developing countries, institutional capacity

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1. INTRODUCTION

In recent times, it has been recognized that digital technologies have a transformative effect on governance functions, government capacity, and sustainable development goals [1],[2],[3] The success of digital transformations depends on the existence of integrated government information systems and infrastructures that can operate seamlessly across nations [3],[4],[5]. More importantly, it should be noted that the true worth of technology lies not in its adoption but in its transformative capacity to restructure processes and governance systems [6],[7],[8]. Identifying the research and training needs required to leverage such disruptive technologies is therefore a critical prerequisite for successful digital government transformation [4]. Thus, digital technologies should be aligned to wider public sector policy and reform processes [9],[10].

The adoption of e-government in developing nations during 2020-2025 exhibits a complex range of socio-political conditions, technological readiness levels, and institutional capacity that differ from trends in developed nations [1],[2],[11]. Regional disparities continue in the form of connectivity, accessibility, and digital divide issues in developing countries, whereas developed countries concentrate on value-driven optimization [12] Quantitative evidence confirms that digital transformation positively impacts governmental efficiency, particularly when integrated with broader administrative reforms [13]. With this context in mind, Government 3.0 refers to an advanced stage of digital governance characterized by data-driven, citizen-centric, and proactive service delivery, where governments leverage emerging technologies such as artificial intelligence and big data to anticipate citizens' needs, enhance transparency, and enable participatory decision-making. is on the rise, and artificial intelligence and blockchain technologies have received considerable attention from researchers. Artificial intelligence is increasingly recognized as a key technology for improving government services through automation and data-driven decision-making [14],[15],[16],[2],[17].

Blockchain technology is widely recognized as a key technology for supporting transparency, integrity, and trust in digital government systems, particularly in contexts where data security and accountability are critical [18],[19],[20],[21],[22] Their integration is increasingly regarded as a foundation for smart governance for developing countries facing challenges of accountability and legitimacy [16],[23]. Smart city initiatives are

another area where digital platforms and policy frameworks are regarded as the basis of administrative innovation [24]. Take, for example, India's Digi Locker and Aadhaar initiatives, regarded as the basis of welfare delivery [25],[14],[18], while self-sovereign identity systems are being explored for improving the quality of digital governance [25].

In the African continent, the use of blockchain technology for land registration is being explored in Kenya and Ghana [26], while the IremBoGov system is regarded as the basis of the potential of artificial intelligence (AI) systems for digital governance. However, the challenges facing digital governance are significant, both from the perspectives of technology, data security, and institutional dimensions [27]. The challenges facing digital governance are data privacy, international data governance, and security risks [28],[29]. This tension between blockchain's immutability and 'the right to be forgotten' is still debatable [30],[31],[16], as well as cybersecurity threats, though cybersecurity governance through AI is believed to improve digital trust [32]. Although more research is being conducted on AI and blockchain in public administration, existing research is fragmented in its coverage of technological, organizational, and legal dimensions of AI and blockchain, which is mostly analyzed in isolation from each other through integrated theoretical lenses [33],[35],[34] [35]. Systematic reviews on the combined impact of AI and blockchain on e-government systems in developing countries are still limited. Most existing reviews used qualitative methods in various countries [36],[37],[38] using a bibliometric approach on general trends. Despite the growing body of research on artificial intelligence and blockchain in public administration, existing studies remain fragmented, often examining technological, organizational, and regulatory dimensions in isolation.

Furthermore, systematic reviews that explicitly analyze the combined role of AI and blockchain within the Government 3.0 paradigm in developing countries remain limited, particularly those that integrate institutional and governance perspectives. The central problem addressed in this review is that while AI and blockchain are increasingly promoted as key enablers of Government 3.0, existing evidence in developing-country contexts remains fragmented across three interrelated dimensions: (1) technological studies often ignore institutional and regulatory constraints; (2) governance and public administration research rarely examines the combined effect of AI and blockchain; and (3) no existing systematic review has explicitly integrated technological, institutional,

regulatory, and trust dimensions within a Government 3.0 framework for developing countries

Consequently, policymakers lack evidence-based guidance on the conditions under which these technologies contribute to sustainable digital governance. To address this problem, this study conducts a systematic literature review following the PRISMA 2020 protocol. Unlike bibliometric or meta-analytic approaches, a systematic review allows synthesis of empirical, conceptual, and qualitative evidence to identify patterns of barriers, facilitators, and governance implications. The review focuses on studies published between 2020 and 2025, examining the adoption of AI and blockchain in e-government systems in developing countries. Based on the synthesis, the study proposes the SIF-G3.0 conceptual framework to guide future research and policy discussions. The novelty of this study lies in its integrative approach, which synthesizes technological, institutional, and regulatory dimensions within a unified analytical framework. The study contributes to the literature by providing a structured synthesis of recent research, identifying key adoption patterns and research gaps, and offering a theoretically informed framework to support future research and policy discussions in digital governance [39].

2. METHODOLOGY

2.1. Study Design and Rationale

The systematic review comprises 99 studies published between 2020 and 2025 regarding AI and blockchain technologies in DG, which reveal gaps and avenues for future research [40],[41] This method considers the diversity of concepts, methods, and contexts found in various developing economies while examining the adoption of technologies, capacity building, political will, and regulations [42],[43]. This method enables the identification of patterns and mechanisms while considering various constraints and enablers found in various developing economies (Section 2.8). This method addresses various socio-political constraints beyond quantitative measurements [31],[44]. This systematic review follows the PRISMA 2020 protocol [45],[46]. This method ensures the quality and validity of the qualitative findings [18],[44].

2.2. Protocol Registration and Ethical Considerations

The review protocol was registered on the Open Science Framework (OSF) (DOI: 10.17605/OSF.IO/ZH7G6), which promotes scientific openness and avoids duplication of work. It ensures that the review process is completed following a pre-specified sequence of methods, which is highly effective considering the application of various methods for data collection in the studies [31],[45],[18].

2.3. Analytical Framework (PECO/PICO)

Analytical rigor was ensured for the review of the studies on the barriers and facilitators of the application of AI, Blockchain, and other relevant technologies to improve efficiency, security, and citizen-centric Government 3.0 models [45],[42]. A pilot review of 15 studies confirmed the identification of the PECO framework and the absence of new concepts like Quantum Secure Trust Protocols (QSTP) in 2020-2025, which will be explored further [47]. The operationalization of the analytical framework is provided in Supplementary Material A (Table S1).

2.4. Research Question

What are the key barriers and facilitators influencing the adoption and integration of Artificial Intelligence (AI) and Blockchain technologies within Government 3.0 (G3.0) frameworks in developing countries (2020–2025), and how do these technologies, when combined, enhance efficiency, transparency, accountability, and trust in public service delivery compared to conventional e-government systems?[1],[31],[45],[7].

2.5. Search Strategy and Information Sources

The literature search was mainly performed using Google Scholar with additional backwards and forwards citation analysis as well as snowballing. This was chosen as an appropriate method since the topic includes several disciplines: information systems, public administration, governance, cybersecurity, digital transformation and others. As a result, literature on those topics is distributed across multiple journals and publications rather than concentrated in a single indexing system. To increase transparency of the research process, the search string included pre-defined Boolean searches combining various technological, administrative, and evaluation aspects of the problem, which can be seen in Tables S2 and S3 (Supplementary Material B). The search covered scholarly

literature published between 2020 and 2025 as a period that guarantees relevance and recency of the articles found. Moreover, backward and forward citation analysis, along with snowballing, helped in finding key influential works and related studies that would have been missed during pure keyword searching. However, Google Scholar may be considered a limitation of this search methodology due to indexing variability and database coverage limitations and limited access for some types of resources. Nevertheless, such limitations are addressed by the study through implementation of explicit inclusion criteria, protocol registration, application of PRISMA guidelines, and other quality methods.[42][18][44]

2.6. Inclusion and Exclusion Criteria

Strict predefined criteria were applied to ensure academic quality and topical relevance. The selection criteria covered publication timeframe, study type, language, and topic focus. Full details of the search string and eligibility criteria are provided in Supplementary Material B (Table S4).

1) Included document types

a) Journal articles (from peer-reviewed and indexed journals)
b) Conference papers (from proceedings, regardless of peer-review status)
c) Conceptual and theoretical framework papers
d) Systematic literature reviews and bibliometric studies
e) Technical reports and preprints (only if they contained original data or substantive analysis and met the quality threshold)

2) Excluded document types

a) Editorials, opinion pieces, book reviews, and commentaries
b) White papers and grey literature without verifiable methodological information
c) Non-English publications
d) Studies published before 2020 or after 2025
e) Studies focused exclusively on developed countries without clear implications for developing contexts

3) Other criteria

a) Timeframe: 2020–2025 (inclusive)

b) Language: English only

c) Geographic focus: Developing countries as defined by the World Bank (low-income, lower-middle-income, and upper-middle-income economies), or studies with explicit implications for developing countries

2.7. Quality assurance for all sources

All 99 included studies, regardless of publication type or peer-review status, were assessed for methodological quality using the CASP checklist. Only sources that met the minimum quality threshold (score ≥ 6/10) were retained. This approach ensures that non-peer-reviewed sources (e.g., preprints, technical reports, unpublished manuscripts) were included only when they demonstrated sufficient methodological rigor. The detailed coding of document types and quality scores is provided in Supplementary Material D (Table S6).

2.8. Study Selection Process and PRISMA Flow

The review process followed a structured PRISMA-based workflow consisting of several sequential stages. First, the search strategy was executed to identify relevant studies. Second, duplicate and irrelevant records were removed during the screening phase based on titles and abstracts. Third, full-text articles were assessed for eligibility according to predefined inclusion and exclusion criteria. Fourth, the selected studies underwent quality assessment to evaluate their methodological rigor. Finally, the validated studies were synthesized to identify key themes, patterns, and relationships, which informed the development of the proposed SIF-G3.0 conceptual framework. The study selection followed the PRISMA 2020 multi-stage flow, ensuring a transparent and reproducible screening and selection process and resolving reviewer discrepancies independently. [41],[47]. PRISMA Flow Description in Figure 1 shows the process for identifying, screening, evaluating, and including eligible studies in this systematic review (2020-2025). Note: The high number of inaccessible full texts may affect the completeness of the review.

1) Identification: 2,365 records

2) Deduplication: 31 duplicates removed, 39 excluded automatically → 2,295 records

3) Screening: Titles/abstracts screened, 1753 excluded for irrelevance
4) Eligibility: 542 sought, 391 full texts unavailable, 151 assessed
5) Final Exclusion: 52 excluded (38 wrong type, 14 incomplete/unclear methodology)
6) Inclusion: 99 studies included [31],[44]

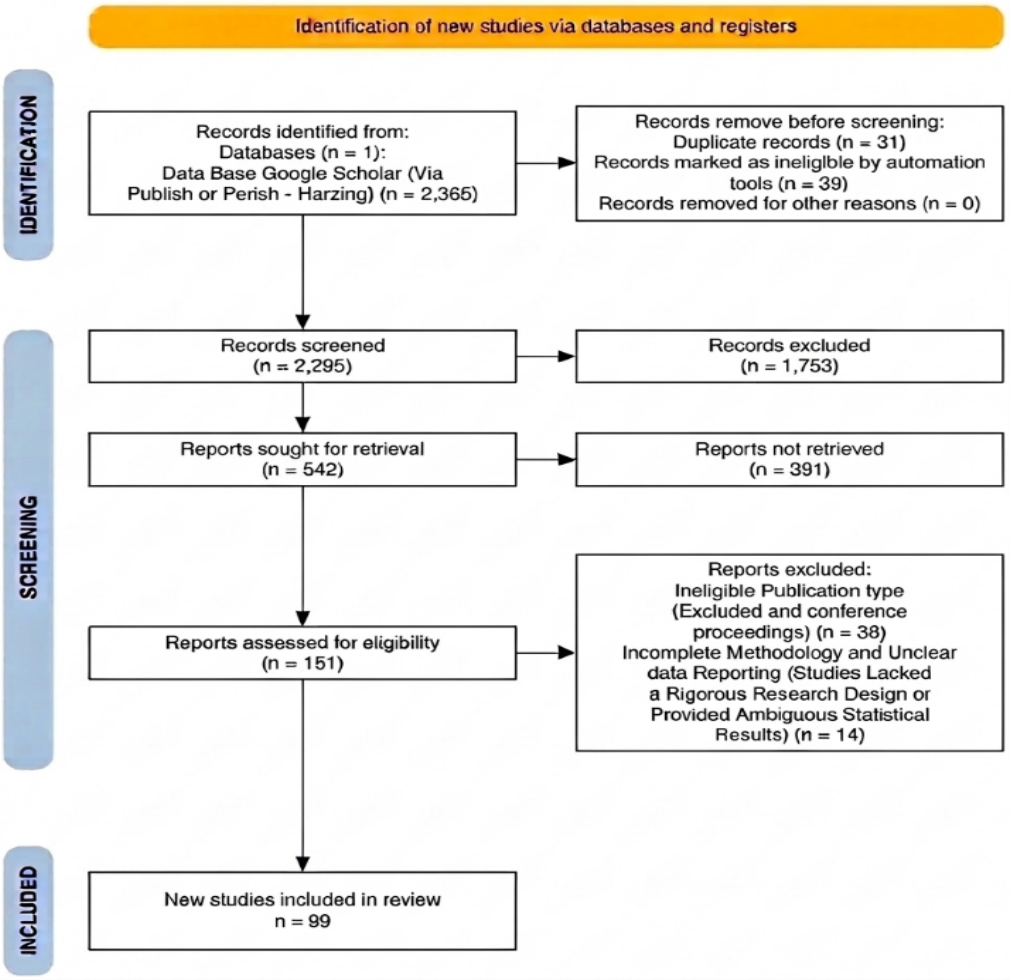

Figure 1. PRISMA 2020 flow diagram

2.9. Data Extraction and Quality Assessment

The use of a standard template for data extraction ensured consistency in the approach for all included studies [42],[43], including author, publication year, location, methodology, technology, results, barriers, and enablers. Data was coded relationally to match the themes, maintaining context-specific differences.

For assessing the methodological quality, the CASP checklist was used to evaluate rigor, research purpose, study design, data analysis, and coherence. The scoring system helped in comparing multiple studies, and this was ensured for both qualitative and quantitative research in various socio-technical contexts [18],[46]. Results of assessing the quality and risk of bias for all the 99 studies are provided in Supplementary Material C (Table S5). To ensure objectivity and minimize the potential for bias, the selection and quality assessment of studies were conducted independently by two researchers (the first and second authors). The reviewers' agreement was calculated using Cohen's kappa coefficient, which was 0.85, indicating excellent agreement. The initial agreement rate among the reviewers was 92%. Disagreements were resolved through collaborative discussion until consensus was reached, further enhancing the objectivity and reliability of the review, in accordance with procedures followed in previous systematic reviews in this field [46],[40], Supplementary_Table_S12_Cohen_Kappa_Agreement

Scoring (1-10)

1) 10: High methodological quality, including quantitative research, robust designs, and/or top-tier systematic reviews
2) 9: Quantitative and/or qualitative research of good quality
3) 8: Qualitative research, solid systematic reviews, and solid case-based research
4) 6-7: Narrative, theoretical, and interpretive research
5) <= 5: Research with serious methodological limitations and poor transparency

Coherence

1) High: Good alignment between objectives, methodology, and results
2) Medium: Limited transparency in methodology, not replicable
3) Low: Limited transparency, poor alignment between objectives and results

Fully included: good quality, low risk of bias research Included with reservations: Good quality research based on theory and secondary research.

3. RESULTS AND DISCUSSION

This section integrates both the presentation of findings and their interpretation to provide a cohesive synthesis of the reviewed evidence. Although the findings provide

descriptive trends, the analysis goes beyond simple frequency reporting. Instead, the analysis delves into the interpretation of the findings, including the relationships, differences, and dynamics. The findings of the study, which include the themes of technological readiness, institutional capacity, regulatory frameworks, and trust, are explored as integrated factors influencing the adoption of AI and Blockchain, as guided by the SIF-G3.0 framework.

3.1. Study Selection and Overview

A rigorous search process in accordance with the PRISMA 2020 protocol identified 99 The review included empirical, conceptual, bibliometric, and systematic review studies relevant to AI, blockchain, and Government 3.0 in developing-country contexts. on the adoption of AI and Blockchain in e-government in developing nations in 2020-2025 [40],[48]. The search process began with a total of 2,365 articles. After removing 31 duplicates and 39 articles with indexing problems, there were 2,295 articles to screen. This was followed by a title and abstract review, resulting in 1753 articles remaining. The full texts of 151 articles were accessible, whereas 391 articles were not accessible [40], [49]. Based on the predetermined criteria, 52 articles were excluded: 38 articles were excluded due to research type criteria, and 14 articles were excluded due to methodology criteria.

3.2. Descriptive Characteristics of Included Studies

In this section, the timeline and geographic progression of the research on AI and blockchain within the context of e-government will be presented.

3.2.1. Temporal Distribution of Studies

The number of publications increases over the years, reflecting a growing global interest in smart e-government. The earlier works focused on the digitalization of government services and their online delivery. However, recent works highlight the use of AI for decision-making and blockchain for transparency. The recent works are dominated by the years 2024-2025, reflecting the emergence of generative AI and blockchain technology [27],[50].see Supplementary Material D (Table S7) for the detailed temporal distribution of studies.

3.2.2. Geographic Distribution of Studies

The body of knowledge on the subject is diverse, with a bias towards developing economies. The sample size varies from expert opinions based on a sample of 21 individuals to real-world data with a sample size of over 3,800 observations [51]. However, advanced economies are represented by more theoretical works. The details are shown in Supplementary Material D (Table S8). Asia dominates the publication scene, with China and India being prominent countries. These countries are actively pursuing AI. In the Middle East region, countries such as Iraq, Saudi Arabia, UAE, Jordan, Egypt, and Iran are prominent, reflecting changes in laws and preparedness for the new technology. In Africa, digital inclusion and adoption are prominent. The focus in Africa has been more on digital inclusion and the gaps that influence the adoption process [8],[52]. The case of Iraq shows an increase in internet penetration from 3% in 2010 to 74.9% by 2023. However, the growth in E-Government Development Index is not uniform [53].

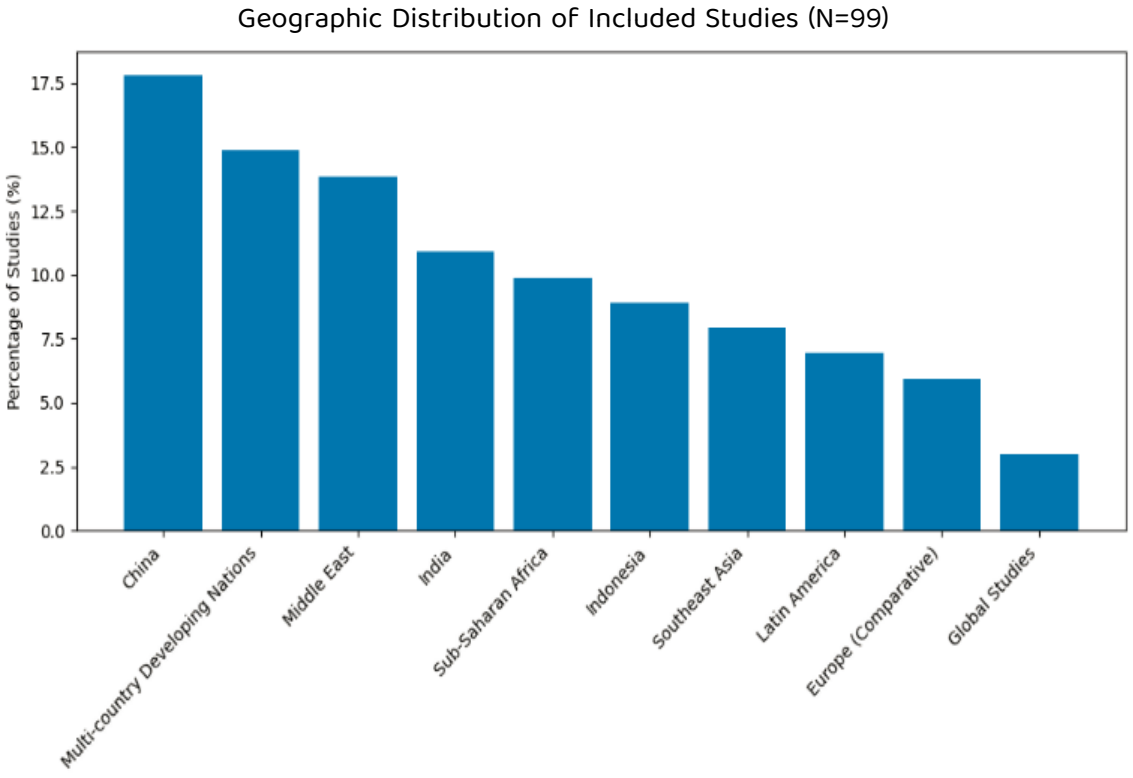

Figure 2. Regional share of empirical studies.

The regional distribution is analytically important because it shows that the evidence base is geographically uneven rather than globally balanced. The dominance of Asia

suggests that the current synthesis is strongly influenced by governance experiences from rapidly digitizing Asian contexts, while the comparatively lower representation of Africa and the Americas indicates that some region-specific barriers may remain underexplored. This imbalance should be considered when interpreting the generalizability of the review findings.

3.2.3. Sectoral Contexts and Application Domains

The research on the use of blockchain and AI in EG has specifically looked at administrative domains that require the management of intricate data, as well as high degrees of accountability. These have included healthcare administration, financial services and insurance, smart city management, education systems, and logistics/public supply chains [31],[18]. For instance, a blockchain-based fraud detection system was proposed for public ration distribution to enhance transparency and reduce leakage in government welfare programs [68]. Specifically, in the area of telemedicine, blockchain technology is used in the verification of data, related to clinical interoperability standards, where AI improves predictive diagnoses and resources optimization. In smart city management, AI and blockchain technology collaborate in linking IoT devices for improved service efficiency. A prime example of this is the use of X-Road technology in Estonia, where secure inter-organizational data exchange is enabled, facilitating an integrated approach to digital government and improved public service delivery. Sample sizes for research have ranged from 21 experts to over 3,800 observations. A prime example of empirical research in EG is the research into the Beijing smart government platform, where the Kano Model was employed, collecting 648 validated citizen responses to measure the guidance, interaction, processing, and evaluation stages [7], On a local government level in Indonesia, the design and development of a community service information system website in Pakuhaji District further illustrates how digital transformation initiatives are being operationalized at the district level in developing countries [55].

3.2.4. Technology Domains and Research Focus

The technological distribution of studies within the “evolving governance priorities” framework reflects a shift in governance priorities towards relying on digital technologies to enhance transparency, efficiency, and decision-making. This distribution

also reflects the growing importance of smart governance, cybersecurity, and data management in reshaping public policies and keeping pace with digital transformation.

Table 1. evolving governance priorities

Technology Domain	Number	Percentage (%)
Artificial Intelligence & Smart Government Platforms	34	34.65
Blockchain / Distributed Ledger Technology	25	25.74
Cybersecurity Systems	15	14.85
Smart Cities Infrastructure	13	12.87
Digital Identity and Sovereignty	12	11.89

Artificial Intelligence is central to discussions on predictive analytics and AI-driven decision-support systems, while Blockchain complements AI by enhancing transparency, traceability, and inter-organizational data sharing. Digital identity initiatives, such as Indonesia's E-KTP, illustrate how biometrics and centralized population data can enable safer public services in digital government systems [56], Similarly, Intelligent Public Sector Automation (IPSA) frameworks have been proposed to systematically integrate AI-driven process automation within public administration workflows, addressing both strategic opportunities and implementation challenges [57]. This focus suggests the emergence of hybrid intelligent governance systems. This distribution suggests that the literature is moving beyond basic digitalization toward hybrid governance models that combine intelligence-oriented functions with integrity-oriented infrastructures. The prominence of AI-related studies reflects increasing interest in predictive and automated public service delivery, while the strong presence of blockchain-related studies indicates that transparency, traceability, and trust remain central concerns in digital government transformation.

3.3. Methodological Characteristics and Analytical Approaches

Research on Blockchain and AI adoption in e-government shows considerable methodological diversity, reflecting the multidisciplinary nature of digital governance, spanning information systems, public administration, data science, and organizational management. Recent studies propose frameworks for structured transparency

assessment, adaptive digital investment models, and architectural designs for digital service infrastructures [58],[59],[16][58].

3.3.1. Distribution of Research Designs

Among the 99 studies, research designs include quantitative, qualitative, mixed-method, and conceptual approaches (Table 2).

Table 2. Methodological Approaches of Included Studies (N = 99)

Study Design	Number	Percentage (%)
Quantitative Empirical Studies	42	42.57
Qualitative Case Studies	27	27.72
Mixed-Methods Research	18	17.82
Conceptual / Theoretical Studies	12	11.88
Total	99	100

Quantitative research is still the most prominent in the field, with structured surveys remaining the primary method of measurement in how people accept the technology, how capable the organizations are, and how the people trust the system [7]. However, there is an emerging trend of using mixed research methods, where the research is initially qualitative and then quantitative validation is carried out as a backup. This methodological distribution indicates that the field is empirically active but still theoretically fragmented. The dominance of quantitative studies reflects a strong emphasis on measuring adoption, readiness, and acceptance, whereas the smaller proportion of conceptual studies suggests a continued need for integrative frameworks that connect technological, institutional, and governance dimensions. This imbalance helps explain the need for the present review and for the development of the SIF-G3.0 framework.

3.3.2. Quantitative and AI-based Analytical Techniques

Advanced statistical methods are used to examine inter-relationships among perceived usefulness, institutional trust, governance quality, and behavioral intention. Partial Least Squares Structural Equation Modeling (PLS-SEM) is widely applied [60],[61],[48], while

Ordinary Least Squares (OLS) regression and panel data techniques address macro-level effects. Short- and long-term impacts of e-government policies are assessed via Autoregressive Distributed Lag (ARDL) [50]. ANOVA and mediation-moderation techniques further analyze demographic and organizational factors. Complementing these, AI-based techniques, including machine learning and decision tree modeling, support performance measurement, risk forecasting, and fraud detection [62], [63],[64]. Integration with blockchain-based predictive models enhances monitoring reliability and system accountability.

3.3.3. Qualitative Approaches and Methodological Trends

Interpretive and grounded research approaches using NVivo and ATLAS. To identify governance challenges and adaptation trends [48]. Grounded theory is particularly valuable in early blockchain studies, ensuring greater validity. Although research is diverse, most studies remain cross-sectional, limiting generalizability. Randomized experiments are uncommon due to ethical constraints. The field is gradually shifting toward integrating statistical modeling, machine learning, and qualitative research to evaluate governance performance rather than focusing solely on exploratory blockchain adoption.

3.3.4. Sample Characteristics and Data Sources

Survey sizes range from 120 to 495 participants, including citizens, employees, or experts, with expert panels of 10–21 members. Administrative datasets often exceed 3,000 cases [56]. A smart government survey in Beijing yielded 648 validated responses [7].

3.4. Barriers and Opportunities for Blockchain and AI Adoption

E-government in developing countries is influenced by several factors—technological, institutional, organizational, and socio-cultural. Together, they play a crucial role in deciding whether e-governance will take deep roots or remain confined to pilot projects. From a total of 99 studies, four main groups of barriers/opportunities were identified—covering all aspects of the analysis scope.

3.4.1. Overview of Adoption Themes

These thematic clusters were identified as: institutional and regulatory barriers, technological constraints, organizational readiness, and digital trust and security. Focusing specifically on technological enablers, research on cloud computing adoption in local governments confirms that organizational readiness and environmental factors play decisive roles alongside purely technical considerations [65],Of these thematic clusters, institutional factors were found to be the most dominant, as they were identified in 32 studies (31.68%), implying that the adoption of AI and Blockchain technologies in e-government is more dependent upon the governance and institutional capabilities of the country than the availability of these technologies. The other thematic clusters were almost equally represented as they have interdependent roles to play as enablers, which is in line with the systemic perspective of the SIF-G3.0 framework. A breakdown of these thematic clusters for all 99 studies is presented in Supplementary Material D (Table S9). The dominance of institutional barriers can be explained by the fact that AI and blockchain adoption in e-government depends not only on technological availability but also on administrative structures, implementation capacity, inter-agency coordination, and policy continuity. In developing countries, weak institutional readiness often determines whether these technologies remain pilot initiatives or become operational governance tools. This explains why institutional barriers appear more consistently than purely technical barriers across the reviewed studies.

3.4.2. Trust, Security, and Socio-Cultural Dimensions

The concept of trust permeates 22 studies as an underlying theme. The immutable nature of blockchain technology is associated with improvements in transparency, security, and trust in digital governance [66],[67],[31]. Moving beyond identifying isolated trust antecedents, recent research emphasizes the need for comprehensive trust frameworks that systematically integrate multiple dimensions of trust in digital government systems [68],E-government platforms are likely to enhance transparency and minimize corruption risks, subject to data management and privacy considerations [69],[70]. Digital accountability is associated with greater oversight, transparency, and trust, which may contribute to improved governance performance [70],[71]. Socio-cultural dimensions and digital literacy are key factors in the success of adopting blockchain technology in developing countries [46], A more recent analysis in a leading public administration

journal tempers this optimism, however, by revealing that the 'hype' surrounding blockchain in government often outstrips its actual implementation, and that its touted benefits for transparency and trust are highly contingent on specific institutional and governance contexts [72].

3.4.3. Integrated Adoption Dynamics

The interaction between blockchain and AI is complementary rather than merely parallel. Blockchain provides secure, transparent, and tamper-resistant data infrastructures, while AI uses those data for predictive analytics, automation, and decision support. In practice, blockchain enhances the reliability and auditability of the data environment on which AI operates, whereas AI increases the functional value of blockchain-based systems by transforming verified data into actionable administrative intelligence. This interaction is particularly relevant in public-sector applications such as fraud detection, service optimization, digital identity systems, and performance monitoring. From a regulatory compliance perspective, blockchain technology can also play a critical role in enhancing AI governance by providing immutable audit trails that support adherence to emerging legal frameworks such as the EU AI Act [73].

3.5. Empirical and Statistical Evidence

In all cases, Blockchain and AI suggest potential in the development of e-government. Structural equation modeling (SEM), particularly using the partial least squares method (PLS-SEM), assesses institutional readiness, technological factors, and citizen acceptance, with values ranging from 0.35 to 0.68 [61]. Regression analysis, autoregressive distributed lag (ARDL), and analysis of variance (ANOVA) further reinforce adoption and effectiveness [50]. Decision tree classifiers achieve as high as 97.4% accuracy in digital readiness assessment [62], whereas blockchain-based fraud detection achieves AUC of 0.947 [21]. Digitally enabled procurement and vendor management increase operational efficiency [56],[74]. Furthermore, empirical evidence confirms that e-government implementation positively contributes to economic efficiency, reinforcing the broader macroeconomic benefits of digital governance transformation [75], Overall, the research findings provide indicative evidence in support of performance-driven evaluation of e-government.

3.6. Discussion

3.6.1. From Technology Acceptance to Institutional Sustainability

The majority of research relies on TAM and UTAUT as the underlying constructs for the acceptance of Blockchain and AI in e-government [71]. A recent empirical study on the SANAD app services further validates that integrating UTAUT with TAM, TPB, trust, and perceived risk provides a more comprehensive understanding of citizen adoption behavior in e-government contexts [76],The constructs of trust are consistent in linking the acceptance of Blockchain and AI with the quality of the system, security, and transparency in e-government [71]. The application of broader constructs such as trust theory and agency theory [71], resource-based theory [11], and the diffusion of innovations theory [42], is evident in the assessment of organizational readiness, infrastructure, and policy diffusion. The SIF-G3.0 model attempts to synthesize the various constructs of e-government sustainability, focusing on the institutional alignment of technological infrastructure, regulatory architecture, organizational capacity, and legitimacy mechanisms, thereby shifting the paradigm from individual acceptance to institutional sustainability. The various theoretical frameworks underlying research on the adoption of Blockchain and AI in developing countries are summarized in Supplementary Material E (Table S10). From that theory base, it is evident that blockchain primarily enhances institutional credibility in terms of transparency and auditability, while AI enhances governance in terms of supporting predictive decision-making and service optimization. However, as the adoption, trust-based, and institutional theories converge, they seem to indicate the emergence of a new trend of hybrid approaches that could potentially encompass the intentions behind the use of such technologies as well as the impact on the institutions of governance.

3.6.2. Quality Assessment and Risk of Bias

The quality check of the methods shows that the overall research rigor of the studies was good. In the 99 studies, 61 were classified as high, 30 as moderate, and 8 as low in overall quality. The 8 studies that were classified as low were included with some caution, as they were theoretical in nature. If we consider the overall quantitative studies, the reliability of the studies was good, with Cronbach's alpha ranging from 0.82 to 0.95. However, some of the major concerns that were noted were that most of the studies were conducted in a particular geographic area, and most of the studies were perception-

based surveys, which may not allow the findings to generalize across different types of governance situations [31]. A concise description of the quality assessment is presented in Supplementary Material C (Table S11), while the detailed scoring of the studies is presented in Supplementary Material C (Table S5).

3.6.3. Integrated Evidence Synthesis and Theoretical Interpretation

This section synthesizes the reported evidence identified across the reviewed studies regarding the interaction between AI, blockchain, and Government 3.0 systems in developing-country contexts. The literature converges on the emergence of hybrid intelligent governance systems that combine blockchain-based transparency infrastructures with AI-driven analytical and predictive capabilities. These systems appear to be more effective when deployed as complementary rather than isolated technologies, integrating blockchain verification logic with AI optimization mechanisms. Empirical evidence from infrastructure modernization initiatives [77], digital transformation systems [78], blockchain readiness studies [79], and security-oriented e-government architectures [1],[75] supports the emergence of multi-layered integration approaches in digital governance. Across the reviewed studies, blockchain technologies were commonly associated with transparency, traceability, accountability, and secure information exchange, whereas AI systems were primarily linked to automation, predictive analytics, decision-support functions, and service optimization. The reviewed evidence further indicates that successful adoption in developing countries is associated not only with technological capability but also with institutional readiness, regulatory coherence, organizational capacity, infrastructure conditions, and digital trust. Several studies identified trust-related concerns involving accountability, fairness, transparency, and system reliability as recurring factors influencing technology adoption and governance legitimacy. These recurring evidence patterns informed the interpretive analysis presented in the following section [76]. The findings of this review suggest that the adoption of AI and blockchain in Government 3.0 should be understood as an institutional transformation process rather than a purely technological transition. While technology acceptance models such as TAM and UTAUT explain user intentions and behavioral adoption [61], more recent research (2020–2025) increasingly situates these technologies within broader governance transformations characterized by data-driven administration, predictive governance, and digitally mediated decision-making systems [1],[27]. The

reviewed studies indicate that blockchain technologies contribute primarily to transparency, traceability, decentralized verification, and institutional accountability [1],[80],[70],[27], whereas AI systems, including machine learning and language-based models, support anticipatory governance, automated analysis, and algorithm-assisted administrative processes [62],[81],[43]. Together, these developments reflect a broader shift from conventional digital administration toward more adaptive and intelligence-oriented governance structures. The interpretive synthesis further suggests that trust functions as a critical link between technological performance and governance legitimacy. Regulatory coherence, algorithmic transparency, data governance, accountability mechanisms, privacy protection, and cybersecurity frameworks were repeatedly associated with stronger levels of institutional trust and citizen acceptance [44],[5],[82],[83],[84],[85]. At the same time, the reviewed evidence indicates that governance outcomes remain highly context-dependent, particularly across countries with varying cybersecurity standards, institutional capacities, and levels of digital inclusion [86],[87]. Differences in digital literacy, infrastructure accessibility, and citizen capabilities, including forms of "second-level digital divide," further influence the effectiveness and sustainability of Government 3.0 initiatives [47],[7]. Recent legal and governance scholarship also emphasizes the increasing importance of regulatory adaptation and jurisdictional governance as emerging technologies reshape institutional authority, accountability structures, and public-sector legitimacy [88],[89],[90]. Overall, the findings suggest that the long-term effectiveness of hybrid AI-blockchain governance depends on the alignment between technological systems, institutional structures, regulatory environments, and citizen trust mechanisms.

3.6.4. Assessment of Quality of Evidence and Methodological Considerations

The reviewed literature reflects considerable methodological diversity across empirical, conceptual, and interpretive studies of digital governance. Existing research includes quantitative analyses based on Structural Equation Modeling (SEM), regression techniques, and survey-based approaches, alongside qualitative case studies and documentary syntheses emphasizing contextual and interpretive depth [5],[37],[91]. This methodological diversity reflects the multidisciplinary nature of Government 3.0 research, spanning information systems, governance studies, public administration, and digital policy. However, important methodological limitations remain evident across the

reviewed studies. Research conducted in developed-country contexts is more likely to rely on large datasets, formal modeling approaches, and advanced analytical techniques, whereas studies from less-developed contexts frequently employ exploratory, descriptive, or case-based methodologies. As a result, differences in data infrastructure, institutional capacity, and regulatory maturity continue to affect the comparability and generalizability of findings across regions [62],[80],[91]. The evidence base also remains heavily dependent on cross-sectional surveys, pilot initiatives, and perception-based assessments, particularly in politically unstable or institutionally fragmented environments [11],[92] While such approaches provide valuable contextual insights, they often face limitations in evaluating long-term governance outcomes, institutional sustainability, or causal policy effects. Even advanced citizen-centered methodologies, such as the Kano Better/Worse approach applied in the Beijing Jingtong platform study, remain difficult to replicate consistently across different governance settings. Furthermore, contextual conditions including geopolitical constraints, sanctions environments, legal compatibility, and variations in cybersecurity governance significantly influence the trajectory of digital government development across countries [85],[86],[90] Comparative evidence from more mature digital governance systems, such as Denmark, highlights the importance of cohesive national strategies, institutional continuity, and adaptive regulatory frameworks in supporting sustainable digital transformation. Overall, the reviewed evidence suggests that methodological fragmentation and contextual variability remain major challenges in developing a unified body of knowledge on AI-blockchain governance systems.

3.6.5. Strengths and Limitations of the Review

This review has several strengths that contribute to its analytical rigor and relevance. First, the study applied the PRISMA 2020 protocol to ensure transparency, reproducibility, and systematic study selection procedures [44],[2],[27],[53]. Second, the review adopted an integrative perspective by examining AI, blockchain, governance, institutional, and regulatory dimensions simultaneously, whereas many previous reviews focused primarily on technological aspects in isolation [93],[59]. The review period (2020–2025) also enabled the inclusion of recent developments related to generative AI, large language models, cybersecurity governance, digital identity systems, and emerging Government 3.0 applications [43],[7]. Furthermore, the inclusion of empirical, conceptual, and interpretive

studies provided a broader understanding of the evolving governance landscape across developing-country contexts. Nevertheless, several limitations should be acknowledged. The literature search relied primarily on English-language publications, which may have excluded relevant studies published in other languages [40],[53]. Geographic representation within the reviewed studies was also uneven, with stronger concentration in Southeast Asia, the Middle East, India, Indonesia, and Brazil, while other developing regions remained comparatively underrepresented [5],[47],[94]. In addition, much of the existing evidence remains dependent on cross-sectional research designs, perception-based surveys, and exploratory case studies, which may limit the generalizability and long-term interpretive validity of some findings [1]. The rapid evolution of AI technologies and digital governance systems also presents temporal limitations, as technological capabilities and regulatory environments continue to evolve faster than the available empirical literature [37],[95]. Finally, reliance on Google Scholar and citation snowballing may introduce indexing and database coverage limitations despite the application of explicit inclusion criteria and systematic screening procedures. Additionally, while the review included a small number of non-peer-reviewed sources (e.g., preprints, technical reports), all such sources were subjected to the same CASP quality assessment and were retained only if they met the minimum methodological threshold (score ≥6/10).

3.6.6. Practical Implications and Policy Relevance

The findings of this review suggest that successful Government 3.0 implementation in developing countries requires integrated institutional and regulatory strategies alongside technological modernization. The SIF-G3.0 framework highlights the importance of combining AI capabilities, blockchain infrastructures, governance mechanisms, and regulatory adaptation within coherent digital governance systems [23],[27]. For policymakers, the reviewed evidence emphasizes the importance of strengthening institutional readiness, digital governance capacity, and inter-agency coordination before large-scale deployment of AI-blockchain systems. Developing a "digital mindset" within public administration, particularly through data analytics, digital risk assessment, and evidence-based governance practices, may support more adaptive and resilient governance structures [27]. The reviewed studies further indicate that "Government as a Platform" approaches may help reduce bureaucratic fragmentation by promoting collaboration across public, private, and civil society actors [77],[94]. However, successful

implementation depends on leadership continuity, administrative coordination, regulatory clarity, and effective governance routines capable of supporting long-term institutional transformation. Regulatory adaptation also emerged as a critical policy requirement. Areas including data protection, cybersecurity governance, digital identity management, platform regulation, and compliance with data sovereignty and privacy standards such as GDPR were repeatedly identified as central governance concerns [85]. The European Union's approach to governing digital ecosystems through coordinated regulatory frameworks offers valuable insights for developing countries seeking to balance innovation with legal certainty and cross-jurisdictional coherence [96]. In addition, secure digital infrastructures, including cloud-native systems and regulatory technology (RegTech), appear increasingly important for supporting scalable and accountable Government 3.0 systems [95]. The application of digital platform government models in diverse policy domains, such as the promotion of audiovisual content in Brazil, further illustrates the growing relevance of platform-based approaches for achieving public sector goals in developing-country contexts [97], At the same time, the findings highlight the need to address digital inequality and accessibility challenges to avoid excluding digitally vulnerable populations from emerging governance systems [95]. Although AI-based systems demonstrate growing effectiveness in areas such as cybersecurity, fraud detection, and data management [7],[44]. the reviewed evidence suggests that sustainable governance outcomes depend on embedding technological innovation within stable institutional, legal, and administrative structures.

3.7. Recommendations for Future Research

Despite the growing body of research on AI and blockchain in Government 3.0, significant conceptual, methodological, and contextual gaps remain. Future research should further examine how digital governance policies, institutional adaptation strategies, and implementation models evolve across different administrative systems in developing-country contexts, particularly in relation to public-sector reform and digital government transformation [27],[98],[99]. Several important research directions emerge from the reviewed literature.

1) **Longitudinal governance analysis:** Much of the existing evidence remains cross-sectional, limiting understanding of long-term sustainability, institutional adaptation, trust formation, and the unintended consequences of AI-blockchain

governance systems [1]. Longitudinal and comparative studies are therefore needed to evaluate how digital governance systems evolve over time.

Methodological integration: Future studies should integrate quantitative performance evaluation with qualitative assessment of legitimacy, fairness, accountability, and citizen perception in order to overcome the limitations of singular methodological approaches [48], Multi-criteria decision approaches, including Kano analysis combined with AHP or TOPSIS techniques, may offer promising directions for citizen-centered governance evaluation, although broader empirical validation remains necessary [7].

2) **Emerging governance applications:** Additional research is needed on explainable AI, algorithmic accountability, generative AI governance, and human-AI interaction within public-sector decision-making systems, particularly in developing-country contexts where transparency and institutional legitimacy remain significant concerns. Existing research also remains geographically concentrated in regions with relatively higher levels of digital government maturity, while less-developed contexts continue to be underrepresented [47].

3) **Regulatory and political dimensions:** Comparative studies examining differences in regulatory systems, digital sovereignty models, and governance architectures remain limited. Future research should further explore the relationship between digital efficiency, political legitimacy, institutional accountability, and democratic governance. Additional underexplored areas include the environmental implications of blockchain infrastructures, ethical dimensions of AI-assisted governance, and the balance between centralized and decentralized governance systems [1]. Overall, the reviewed evidence suggests the need for stronger theoretical integration across the field of digital governance. Future research may therefore benefit from developing more unified analytical frameworks capable of connecting technological evolution with institutional, regulatory, and socio-political transformation processes. These findings indicate that AI and blockchain adoption in Government 3.0 is conditional upon institutional readiness, regulatory coherence, organizational capacity, and trust, which form the basis for the conclusions presented.

3.8. Institutional and Policy Implications for Advancing Government 3.0 through AI and Blockchain

The reviewed evidence indicates that Government 3.0 transformation in developing countries involves a multidimensional interaction between technological systems, institutional structures, regulatory conditions, organizational capacity, and public trust mechanisms. Rather than representing a purely technological transition, the findings suggest that digital governance outcomes are shaped by the degree of coherence between these interrelated dimensions. Across the reviewed studies, recurring implementation barriers were consistently associated with institutional fragmentation, regulatory uncertainty, uneven administrative readiness, infrastructure limitations, and variations in digital trust. At the same time, AI technologies were commonly linked to predictive governance, automation, and data-driven decision-making capabilities, whereas blockchain systems were associated with transparency, traceability, accountability, and secure information management. Building on these recurring evidence patterns and interpretive findings, this study proposes the SIF-G3.0 model (Structural Institutional Fit for Government 3.0) as a conceptual framework for understanding hybrid intelligent governance systems in developing-country contexts. The framework conceptualizes Government 3.0 as a condition of institutional alignment in which technological capability, regulatory coherence, organizational readiness, and trust mechanisms operate as interconnected dimensions rather than isolated governance variables. Accordingly, the SIF-G3.0 framework shifts analytical attention from technology adoption alone toward the broader institutional conditions required for sustainable digital governance transformation. The framework is directly derived from the recurring relationships identified across the reviewed literature, particularly the interaction between technological infrastructure, institutional capacity, regulatory adaptation, and governance legitimacy. A detailed description of each SIF-G3.0 dimension, including key elements and representative references, is provided in Supplementary Material E (Table S11). Overall, Table 3 provides a structured mapping from empirical evidence to the conceptual dimensions of the SIF-G3.0 framework, ensuring a transparent and systematic derivation of the proposed model.

Table 3. Evidence-to-Framework Synthesis Process

Recurring Evidence from Reviewed Studies	Initial Coding Theme	Interpretive Pattern	Emerging SIF-G3.0 Dimension
Weak administrative readiness, implementation failure, low governance coordination	Institutional readiness	Governance outcomes depend on organizational capability	Institutional Dimension
Legal ambiguity, privacy concerns, GDPR compliance issues	Regulatory governance	Regulatory coherence shapes legitimacy and sustainability	Regulatory Dimension
AI automation, blockchain interoperability, cybersecurity integration	Technological infrastructure	Intelligent governance depends on secure digital systems	Technological Dimension
Citizen confidence, transparency, accountability concerns	Trust and legitimacy	Trust mediates adoption and governance acceptance	Trust Dimension
Digital divide, limited infrastructure, economic inequality	Contextual constraints	Socio-economic conditions shape implementation capacity	Socio-economic Context

The Structural Institutional Fit Model for Government 3.0 (SIF-G3.0) is proposed as a framework to align institutions.

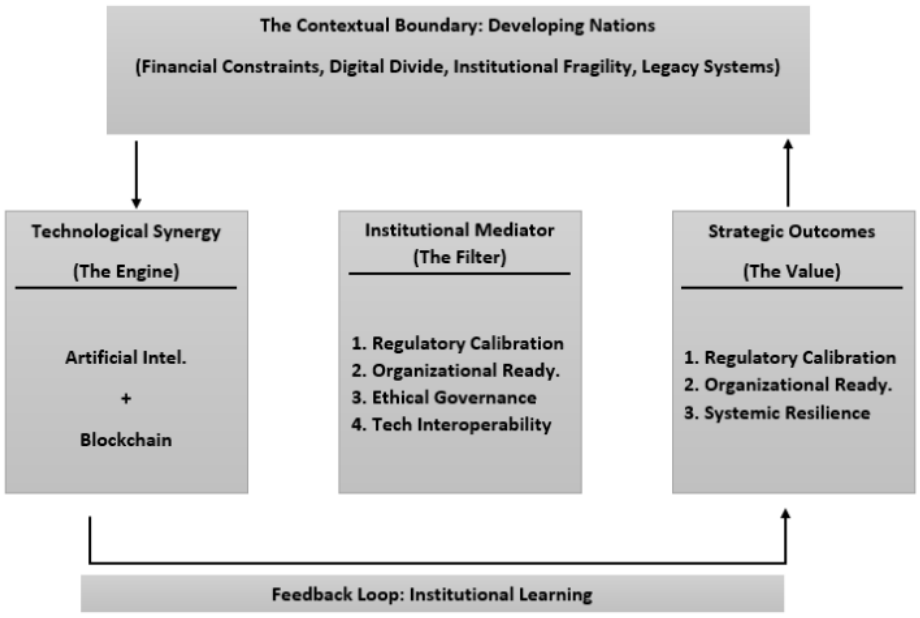

Figure 3. The SIF-G3.0 Institutional Alignment Model

3.9. Theoretical Propositions Emerging from the SIF-G3.0 Framework

Based on the recurring patterns identified across the reviewed studies, the SIF-G3.0 framework generates several theoretical propositions regarding the institutional dynamics of Government 3.0 adoption in developing-country contexts:

- **P1:** The effectiveness of Government 3.0 systems is positively associated with the degree of alignment between AI-blockchain infrastructures and institutional governance structures.
- **P2:** Regulatory clarity and governance coherence positively mediate the relationship between blockchain-enabled transparency and institutional legitimacy.
- **P3:** The contribution of AI systems to governance efficiency is moderated by the presence of accountability, oversight, and explainability mechanisms.
- **P4:** Organizational digital capacity positively influences the sustainability and implementation effectiveness of Government 3.0 initiatives.
- **P5:** Citizen trust in Government 3.0 systems increases when technological capability, regulatory frameworks, and institutional governance mechanisms operate in a coherent and integrated manner.

Collectively, these propositions extend the SIF-G3.0 framework from a conceptual synthesis toward a theoretically interpretable model that may support future empirical testing across different governance environments.

4. CONCLUSION

In conclusion, this review demonstrates that merely introducing terms such as “Artificial Intelligence” and “Blockchain” into governance systems does not automatically lead to improved outcomes in Government 3.0 environments. While AI contributes to enhanced prediction capabilities and process optimization, and blockchain supports transparency and accountability, technological adoption alone is insufficient to achieve meaningful institutional transformation. The findings indicate that the effectiveness of Government 3.0 initiatives is contingent upon a set of critical enabling conditions. Specifically, the adoption of AI and blockchain depends on institutional readiness, regulatory coherence, organizational capacity, and the establishment of trust. These factors collectively determine whether technological innovations can be translated into sustainable

governance outcomes, rather than remaining superficial or symbolic implementations. Importantly, the analysis highlights that efficiency does not necessarily imply transformative impact, and technical transparency does not automatically guarantee institutional legitimacy. Citizen trust emerges as a central determinant, shaped not only by system performance but also by perceived fairness, accountability, and protection against misuse. In this regard, Government 3.0 should be understood as a contingent rather than a universal model, whose success varies across institutional and socio-political contexts. Furthermore, the evidence base remains limited by the predominance of cross-sectional and perception-based studies, raising concerns regarding generalizability and long-term validity. In response, this study proposes the SIF-G3.0 framework as an integrative conceptual model that captures the interaction between technological, institutional, regulatory, and trust dimensions. However, it is important to emphasize that the SIF-G3.0 framework remains conceptual and has not yet been empirically validated. Accordingly, the SIF-G3.0 framework provides a conceptual basis for future empirical testing in developing-country e-government contexts, rather than offering prescriptive or generalized conclusions. Several theoretical and practical implications can be derived from the findings of the present review. From a theoretical point of view, the paper offers a paradigm shift in terms of the emphasis from technology-driven adoption of the discussed technologies towards their institutional alignment, which is associated with the interaction of several key factors including technological maturity, regulatory framework, organizational preparedness, and trust. In terms of practical recommendations, the findings of this research indicate the necessity for policymakers in developing nations to pay special attention to institutional readiness when adopting the discussed technologies.Author

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