***ISSN** (E): 2959-3921*
(P): 2959-393X
***DOI:** https://doi.org/10.59122/EIJET1014*

Ethiopian International Journal of Engineering and Technology (EIJET)
Volume 4, Issue 1, 2026

Current Trends of Designing E-Governance Ontology for Cloud-Based Smart and Trusted Citizen-Centric Services: A Systematic Literature Review

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Abstract

E-governance practices have been transforming citizen-government interactions, enhancing transparency, accessibility, and efficiency in numerous countries. Since each country has its own governance mechanisms, government culture, and systems, a single model framework or ontology cannot be optimally adapted. Current E-governance ontologies, frameworks, and models lack the necessary contextualised adaptability, interoperability, and tailor-made personalisation to fit in the country-specific transformation needs of E-governance, i.e., delivering smart, intelligent, and trusted citizen-centric services. This study presents a summary of key findings from 49 peer-reviewed repositories selected from Web of Science, Scopus, ScienceDirect, Google Scholar, IEEE Xplore, Springer, PubMed, and the ACM Library in terms of research gaps in available features, methodologies, tools and techniques in the cloud-based e-governance models, frameworks, and ontologies. It aims to formulate a problem statement to navigate and guide the futuristic research solutions in the domain. Research articles were screened using the PRISMA 2020 statement guidelines based on significant filtration and selection criteria and then systematically reviewed. Technically, these identified research gaps were listed as 28% of semantic interoperability; 11% noted legal and policy barriers; 15% focused on lack of awareness; 21% mentioned lack of common semantic languages, lack of advanced smart features, and linguistic localization; and 25% notified lack of intra-governance integration for citizen service collaborations. This can help in improving the government's citizen-centric service using the next-generation E-Governance over the Cloud. Another observation indicated that the majority of the reviewed articles were focused on the semantic integration of data and interoperability. Hence, it was concluded based on those research articles that the lack of semantic integration and interoperability issues (28%) are the main challenges for designing the cloud-based e-governance ontology for smart, intelligent, and trustworthy citizen-centric services. Future studies should

***Received**: April 25, 2026; **Revised**: May 4, 2026; **Accepted:** June 8, 2026; **Published:** June 15, 2026*
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focus on developing specific modeling methods for ontology entities, fully implementing and validating proposed solutions in real-world scenarios, and continuing to explore the scalability and adaptability of these architectures to handle growing data volumes and evolving user or citizen demands efficiently.

Keywords: E-governance Ontology, Adaptive Solution, Smart System, Citizen-Centric, Cloud Computing, Intelligent Systems

I. INTRODUCTION

The 21st century is the digital era, where the applications of industrial revolution 4.0 technologies in many aspects have been accelerating the digital transformation of developed and developing countries[1][2]. According to the United Nations survey (E-government survey, 2024), technological innovations have introduced various global and localized government institutions and offices to implement various intelligent and smart technology adoption models in order to maximize transparency, accountability, timeliness, and decision-making. and rapid accessibility to the public[1].

The survey [1] report emphasizes E-governance has emerged as a crucial aspect of modern governance systems across nations, leveraging information and communication technologies to enhance the citizen-centric services in terms of speed, efficiency, transparency, and accessibility. The advancements of cloud computing and trustworthy smart technologies such as Artificial Intelligence in developed or fast-developing countries have been influencing the working culture in their government and business systems by changing the ways they manage data, information, and knowledge for decision-making processes[3].

Cloud computing and its emerging features, such as cryptographic-promised security of mission-critical government information[4], intranet-based internal communication culture transformation [5], effective resource utilization, and autonomic alert systems in e-governance systems[6] and everything under a pay-per-use model under service level agreement [7],[8]made it a sticky and robust technology for the next generation smart governance modelling. These emerging concepts, architectures, models, and frameworks grant motivation for governance systems transformations from traditional Governance or E-governance to smart or intelligent governance systems with improved trust. Several studies[9],[10],[11] revealed that to model E-governance with

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convergence of emerging technologies such as cloud and edge computing, Big data, AI, Blockchain, and IoT have also introduced new smart, intelligent frameworks or models.

However, [12], [13] pointed out that, primarily in the e-governance and public sector domains, existing e-governance frameworks or models have been challenged in providing different types of citizen-centric services and in meeting the evolving requirements of increasing technological complexity and changes in user behaviour and organizational culture.

To make it happen, the scholars[2],[14],[15] recommend that the country needs a new ontology for designing, deploying, and driving the smart governance system towards enhanced trust of citizens[16],[17]. Thus, the next technology intervention may be based on a flexible ontology that can accommodate increasing data and interactions. This structured approach can facilitate the integration of heterogeneous data sources for unified operability and secured, intelligent, consistent, and accurate information or knowledge across various platforms[10].

This study aims to investigate the key features and challenges/limitations of existing e-governance ontologies, models, or frameworks for designing an adaptive e-governance ontology for cloud-based smart and trusted citizen-centric services.

The organization of this article is structured as follows: Section II introduces the literature review; Section III presents the methodological approach for the literature analysis; Section IV describes the results of this study; Section V presents the discussion and research challenges; Section VI summarizes and concludes.

II. LITERATURE REVIEW

A. The role of Cloud Computing in E-governance Models

According to the NIST [18] definition, “Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. Next to the above definition, various authors[19],[20] remarked that the deployment of cloud-based e-governance models can deliver services to the citizens in a far better, efficient, and cost–effective way. The synergy between cloud computing and e-governance is to facilitate enhanced efficiency of business

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processes, provisioning of scalable services to citizens, and bringing cost-effectiveness in public service delivery.

Study [21] indicates that the agility of the cloud computing deployment models empowers the government to deploy its smart and intelligent cloud environments and support the use of advanced technologies such as big data analytics and artificial intelligence (AI). Another study [22] recognized the opportunities of adopting cloud computing within e-governance for sustainable development. Cloud computing fosters innovation and collaboration in e-governance by providing a platform for the development and deployment of new applications and services. Moreover, cloud platforms enable collaboration between different government entities and with external partners, facilitating the sharing of best practices and innovations.

As depicted in Fig. 1, the adoption of cloud computing in governance models can involve deploying one or more services, such as software, platforms, and infrastructure as a service. These services enable government firms to facilitate fast provisioning and re-provisioning of their citizen-centric services, such as data storage, data analytics, collaboration, and communications, to their citizens in any manner and at any time.

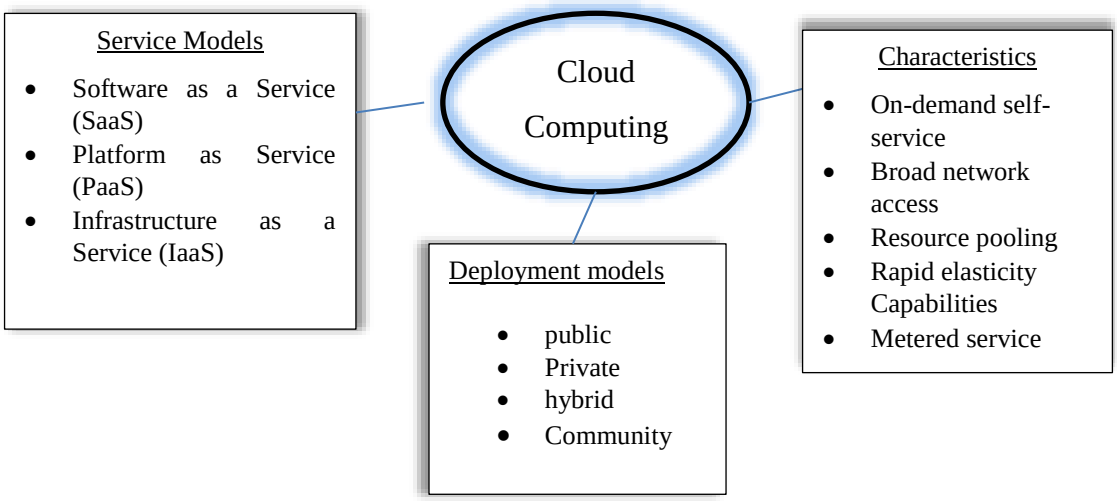

Fig.1. Features and characteristics of cloud computing (NIST)

B. The fusion of Ontology in Cloud-based E-governance

Ontology, in the context of information science and e-governance, is a structured framework that formalizes the representation of knowledge within a specific domain, defining the entities, concepts, and relationships that exist [23]. Ontologies are crucial for achieving semantic

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interoperability, allowing disparate systems to communicate and share data effectively by using a common vocabulary and set of rules. This structured approach facilitates the integration of heterogeneous data sources, ensuring consistent and accurate information across various platforms. Consider the traditional cloud-based e-governance, imagining a scenario where different government agencies all speak the same 'language' (homogeneous) and a citizen needing a permit that involves multiple government agencies (heterogeneous), but this can create difficulties. However, Cloud computing provides on-demand, scalable services, where scalability handles increasing volumes of data and user demands. Finding a solution to the development of ontologies may facilitate data integration, interoperability, scalability and efficient service delivery in a heterogeneous environment [24].

A study [25] showed that one of the most significant advantages of cloud-based ontology modelling is the ability to ensure interoperability between disparate government systems. Considering cloud service models (such as SaaS, PaaS, IaaS, or DBaaS), semantic interoperability becomes a matter of standardizing data formats and protocols. Seamless data exchange and integration are promising to improve collaboration and efficiency across various departments. Further, authors like [26],[27] argued that Cloud-based ontologies can dynamically scale resources up or down, ensuring that Cloud-based application services remain efficient and responsive under varying loads.

III. METHODS

To conduct this Systematic Literature Review (SLR) and the meta-analysis on the "Current Trends of Designing E-Governance Ontology for Cloud-Based Smart and Trusted Citizen-Centric Services," the following research questions guided the investigations:-

Research Question (RQ1): What are the key features towards designing an adaptive, intelligent, smart, trustworthy, and citizen-centric cloud-based e-governance ontology?

Research Question (RQ2): What are the existing e-governance ontologies and their limitations in adapting to dynamic environments?

Research Question (RQ3): What are the identified challenges and limitations in the current design and implementation of e-governance frameworks, models, and ontologies for cloud-based smart and trusted citizen-centric services, and what future research directions are suggested?

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Research objective: The prime objective of this study is to conduct a systematic literature review and meta-analysis to explore the current trends, methodologies, and challenges in designing adaptive e-governance ontology for cloud-based smart and trusted citizen-centric services from the existing research studies.

To achieve the prime goal of the study, this review article conducted a systematic literature review of contemporary and relevant research articles by following a well-designed protocol to identify research gaps. Relevant studies were retrieved from numerous indexing databases where researchers retain and share their research findings. The aforementioned indexing databases were selected based on their reputability, quality, and global acceptance. The databases selected were Scopus, Web of Science, IEEE Xplore, Science Direct, Springer Link, ACM Digital Library, PubMed, ProQuest, MDPI, and Semantic Scholar. Further, the researcher also considered Google Search and Google Scholar to find additional online resources.

In this systematic literature review, the reviewer used keywords such as e-governance ontology, adaptive e-governance ontology, cloud-based citizen services, and semantic technologies for governance, and ontology-driven e-governance service delivery as key search terms for searching research articles.

In combination with those keywords and other wild terms such as evolve, developing countries, Africa, and RDF, our general search strategy is delimited by the following search strings: - (("e-governance" OR "e-government" OR "digital government" OR "smart government") AND ("ontology" OR "ontologies" OR "semantic web" OR "knowledge representation" OR "OWL" OR "RDF")),("e-governance" OR "e-government" OR "digital government" OR "smart government") AND ("ontology" OR "ontologies" OR "semantic web" OR "knowledge representation" OR "OWL" OR "RDF") AND ("Ethiopia" OR "developing country*" OR "Africa"), (electronic governance and ontology) or (electronic governance and knowledge representation) or (electronic governance and ontology and cloud based smart citizen services) or (electronic governance and ontology and intelligent services), (adaptive e-governance ontology) OR (cloud based E-governance ontologies) OR (adaptive e-governance ontology frameworks), (adaptive e-governance ontology) OR (cloud based E-governance ontologies) or (cloud based E-governance semantic web) or (cloud-based E-governance knowledge representation) OR (adaptive e-governance ontology frameworks).

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In this systematic literature review, the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) is used. PRISMA2020 statement [28] updated reporting guidelines for systematic reviews, incorporating advancements in methods for identifying, selecting, evaluating, and synthesizing studies. The PRISMA 2020 statement, as depicted in Fig. 2, was used to help systematic reviewers transparently report the purpose, authors' actions, and findings. It has three essential steps in records: (1) identification; (2) screening; and (3) inclusion. Thus, based on the PRISMA 2020 statement, in the identification step, 343 records are primarily identified from five databases. In the screening step, 232 articles were screened after removing duplicated articles (n=36) and other reasons (n=74); lastly, as Fig. 2 presents, 52 new studies are included for a rigorous systematic literature review.

Identification of studies via databases and registers

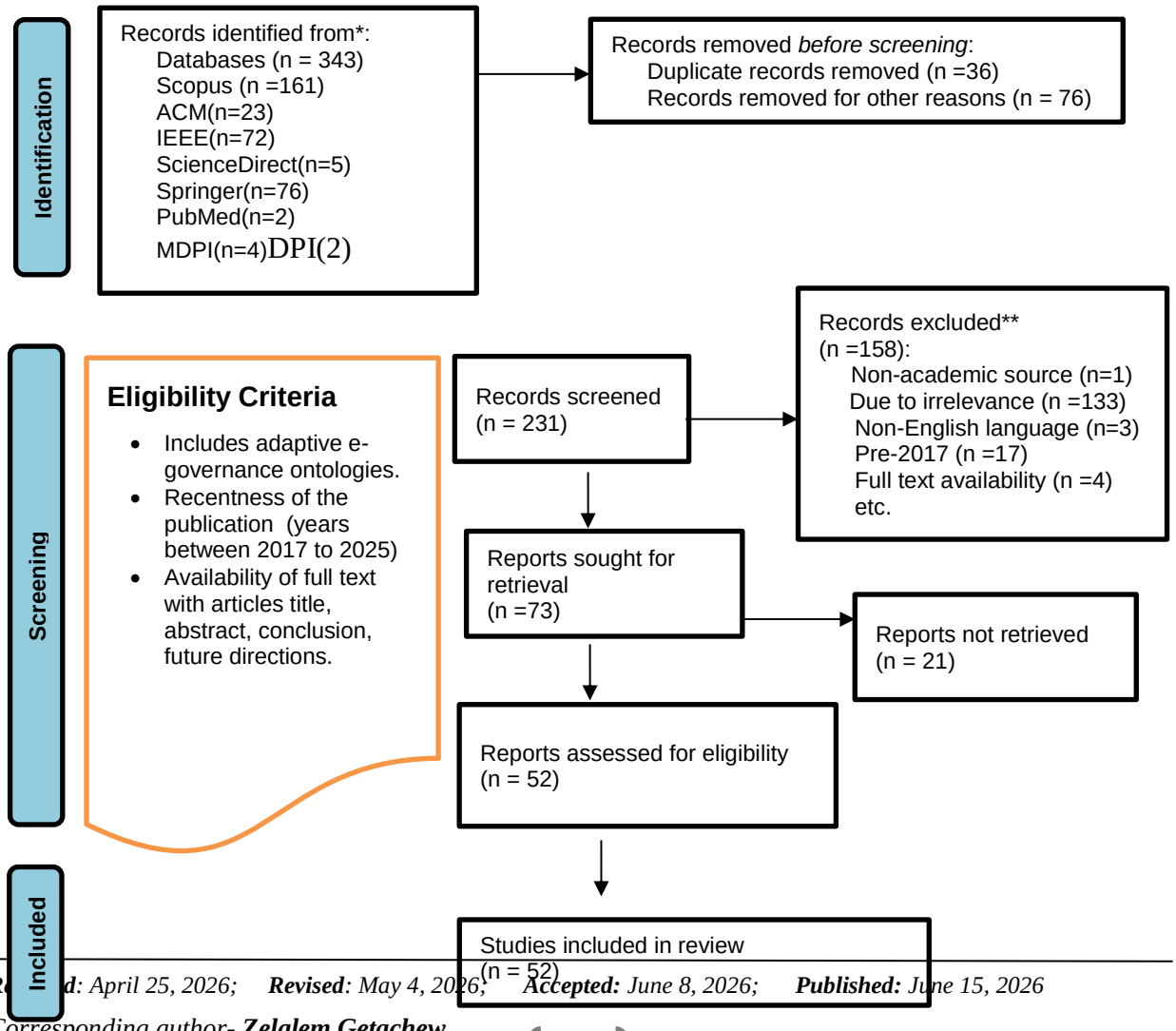

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Fig. 2: Summary of inclusion and exclusion procedures based on PRISMA2020 statement

Out of 52 articles selected for the review (as shown in Fig. 3), 19% of the articles were published in 2017 and 9% in 2025. In terms of indexed databases, as depicted in Fig. 3, most of the research articles (49%) were indexed in Scopus.

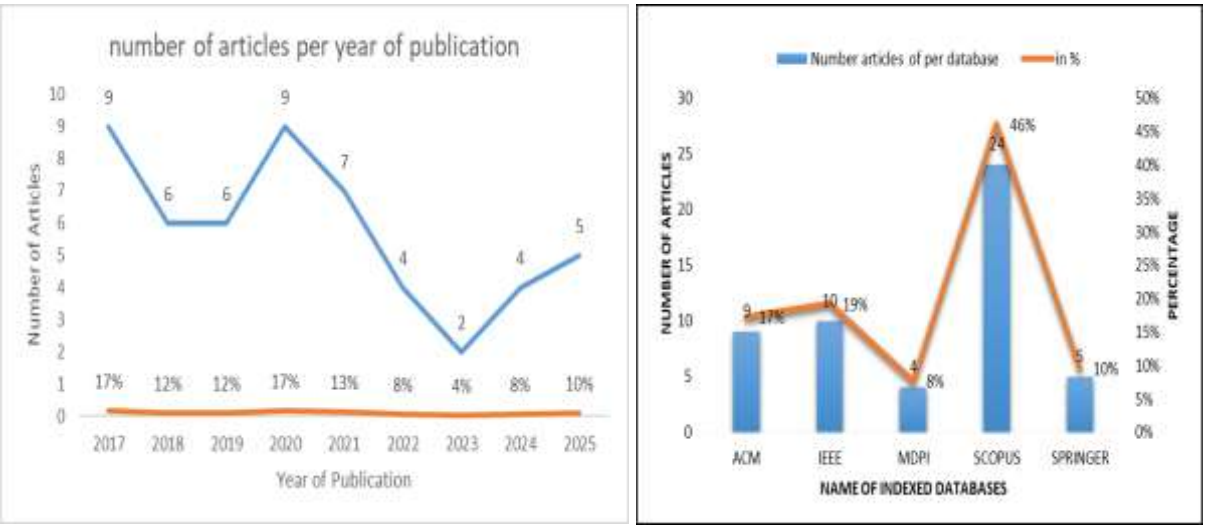

Fig. 3. Summary of publication year to number of articles in each database

IV. RESULTS

In this section, the principal objective of the SLA is addressed through a structured and systematic examination of the main research questions. This is achieved by integrating and synthesizing the results obtained from the three subsidiary research questions outlined in Section III. Each sub-question is analyzed sequentially and coherently, allowing the individual findings to be interconnected and interpreted collectively. Through this comprehensive approach, the analysis culminates in a clear evidence-based response to the central research problem.

Research Question (RQ1): What are the key features towards designing an adaptive, intelligent, smart, trustworthy, and citizen-centric cloud-based e-governance ontology, models, or frameworks?

This SLA generally tried to explore the key features of cloud-based E-governance ontology which have been considered by prior studies, in order to understand their role and their challenges in

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achieving a semantically integrated cloud-based, adaptive, smart, and intelligent E-governance model/framework to citizen-centric service delivery, particularly in Ethiopia. Currently, Ethiopia aims to achieve sustainable E-government principles of "E-government 3.0" [9]. Evidently, the scholars [29] enlisted various ongoing E-services initiatives that envisioned citizen-centric, cloud-based, smart, intelligent digital transformation by 2030. Similarly, authors [20] attempted to design a cloud-based E-governance framework for citizen-centric services to align the country's ICT capacity with the global digital transformation. For now, sources do not contain any information regarding the developed e-governance ontologies within the Ethiopian context.

In the wider context, the review categorizes and summarizes those 52 screened research articles, detailing their primary category (model, framework, ontology, architecture, or others). As mentioned in Table I, most (71%) of the articles focus on the designing and development of different types of models/frameworks, ontological frameworks, and architectures that fit various E-governance requirements. Others (29%) of the articles focus on studying how cloud-based e-governance can be integrated into ontology.

TABLE I

NUMBER OF ARTICLES PER DESIGN FOCUS

References	Design focus	Number of articles
[30], [31]	Architecture	2(4%)
[32], [33],[34], [35],[36],[37],[38], [39],[40],[41],[23],[42],[43]	Framework	13(25%)
[44],[45],[19],[46],[47],[48],[13],[49], [50],[51],[9]	Model	11(19%)
[52],[53],[15], [54],[12] ,[14],[55],[56], [57],[2], [3],[58]	Ontology	12(23%)
[59],[60],[61],[10],[62],[11],[63],[64],[65], [66],[67],[68],[69] ,[70]	Others	14(29%)

Thus, the concept of designing adaptive e-governance ontologies for cloud-based smart and citizen-centric services encompasses various techno-social aspects that reflect a significant paradigm shift in e-governance intelligence [9],[31]. The author of a study [59] recommends the

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importance of a standard framework and a common vocabulary for governmental clouds. Some other scholars [65],[67], under their systematic review, identified key features of existing cloud-based e-government solutions such as adaptability, intelligence, security, interoperability, and citizen engagement. The studies[9],[40] support anticipating citizen engagement in the design phases consistent with technological advancement.

Further, the studies [32], [23],[12] tried to excavate the core benefits of converging advanced emerging technologies such as AI, Blockchain, mobile computing, and cloud computing with e-governance ontologies to foster intelligent, smart, and trustworthy features in the development of government-to-citizen delivery of services, which are addressing complex challenges and enabling advanced capabilities. In conclusion, based on the reviewed research articles contribution offered, Table II presents the identified key features toward designing an adaptive, smart, and intelligent cloud-based e-governance ontology.

TABLE II

SUMMARY OF KEY FEATURES WITH THEIR DESCRIPTION

S/No	Key Features	Description	Reference
1	Smart/ Intelligent	Utilizing Machine Learning (ML), Deep Learning (DL), and Large Language Models (LLMs)	[9][48]
2	Adaptability and Dynamic Knowledge Representation	Cross-phrase semantic similarity & deep learning for ontology evolution	[45][47][23]
3	Trustworthiness and Accountability	To ensure AI algorithms and automated decisions do not undermine social and ethical values	[32], [58]
4	Citizen-Centric	Design principles should elevate citizens from a "customer" role to partners in the co-production of public services	[50],[9]

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5	Cloud-Based	Utilizing a "cloud federated" model allows a central authority to provision services across different data centers.	[59]
6	Interoperability	The ontology to work with multiple technical layers simultaneously.	[60]
7	Scalability	Handling unpredictable and ensuring components operate independently.	[37]
8	Security	Keeping data privacy and confidentiality.	[12]

To sum up, the exploration of multi-dimensional convergence of technologies (Cloud, AI, ML, NLP), for a new e-governance ontology can lead to truly intelligent, scalable, interoperable, smart, and trustworthy, citizen-centric services, by overcoming current challenges such as semantic interoperability, security, data heterogeneity, system integration, and citizen engagement.

Research Question (RQ2): What are the existing e-governance ontologies and their limitations in adapting to dynamic environments?

In designing adaptive e-governance ontologies for cloud-based smart and trusted citizen-centric services, creating structured knowledge representations to enhance public service delivery is emphasized. A primary trend involves leveraging semantic web and ontology technologies to make government data more interconnected and machine-readable, which is crucial for achieving semantic interoperability and overcoming semantic heterogeneity between various web applications and services[68]. Thus, this part of this Systematic Literature Review (SLR) compares existing ontology models, frameworks, and architectures across the provided research articles, focusing on identifying key features(such as adaptability, intelligence, security, and interoperability…) which are considered in the design and development process, while identifying their limitations in dynamic environments.

The Studies[2], [68] noted that the understanding of technical specifications or design focus of existing e-governance model have direct contributes to the upcoming adaptive, smart and intelligent and citizen-centric e-governance services. As it is indicated in Table III, numerous

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scholars represented their multifaceted effort to integrate diversified ontology features, advanced tools (AI, Deep Learning, cloud computing), and robust technical specifications.

Finally, the literature reflects that interoperability remains the foundational goal, and features like adaptability and smartness are now essential for handling the rapid transformation of basic information portals toward data-centric, AI-driven, and adaptive ecosystems. Future research is trending toward autonomous configuration through AI and Knowledge Graphs to bridge the persistent gap between static models and volatile real-world requirements.

However, several systemic limitations prevent these artefacts from maintaining effectiveness in dynamic environments. The authors [60],[11] highlight interoperability as one of the critical challenges that are frequently hampered by naming conflicts (different names for one concept) such as semantic heterogeneity in ontology development. Still, scholars [52] reclaim that the implementation of common semantic standards often faces reluctance from public administrators accustomed to specialized local terminologies. The other abnormality is directly related to developing the nation's ICT infrastructure and the resource gap [37]. A critical lack of digitally stored data and inadequate ICT infrastructure prevents the effective scaling and real-time processing required for modern ontology-based ecosystems.

TABLE III

SUMMARY OF DESIGN ARTIFACTS WITH THEIR DESIGN FOCUS

Reference	**Artifact Name**	**Artifact Type**	**Key Features Addressed**	**Design Focus**
[45]	AD-eGIE	Architecture / Model	Interoperability, Security	Employs deep learning and cross-phrase identification to solve changing data structures.
[59]	GovCloud Taxonomy	Framework / Taxonomy	Cloud-based, Trust, Security	Categorizes models for secure government infrastructure.
[41]	eGovRRC	Framework	Interoperability, Trust	Designed to manage regulatory requirements compliance in system development.
[12],	CSO	Ontology	Security, Cloud-based	Vulnerabilities, threats, and risks in cloud environments.
[39]	Tantra	Framework	Citizen-centric, Trust, Security	The social dimension of citizen information.

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[13]	SCSS	Framework	Smartness, Intelligence, Citizen-centric	Value co-creation through citizen-government data sharing.
[14]	ADM Ontology	Ontology	Interoperability	A vertical ontology developed bottom-up for decentralized Government-to-Employee (G2E) services.
[38]	BTNAD	Framework / Ontology	Interoperability, Trust	Eliminate naming ambiguity and redundancy.
[58]	Web3-DAO	Ontology	Smartness, Trust, Security	Models blockchain-based governance.
[31]	Data-centric Arch.	Architecture	Smartness, Adaptability, Trust	Uses Knowledge Graphs and LLMs
[52]	Moroccan CV	Ontology	Interoperability, Citizen-centric	To present a common vocabulary for national public services.
[37]	e-GSOIF	Framework	Interoperability, Security, Trust	integrates various technological and methodological approaches
[32]	COLABOR-I	Framework	Smartness, Intelligence, Citizen-centric, Adaptability	Focuses on AI-driven e-collaboration and collective decision-making across organizations.
[2]	NigOeGov	Ontology Model	Citizen-centric, Interoperability,	Ontology categorization.
[43]	EA-OE	Framework / Methodology	Adaptability, Interoperability.	Integration of EA (Enterprise Architecture & Ontology Engineering)

Research Question (RQ3): What are the identified challenges and limitations in the current design and implementation of e-governance ontologies for cloud-based smart and trusted citizen-centric services, and what future research directions can be suggested?

As stated in the PRISMA2020 statement [28], synthesis involves the collation, combination, and summary of the findings of individual studies included in the systematic literature review, which is an essential part of a systematic review. This study uses the tabulation technique and a textual approach to synthesize the summarized results. Based on the key features explored in RQ1, this study has rigorously reviewed these 52 related research articles to reveal their ontological design

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concepts, proposed solutions, and research gaps. The details of this study's findings and the explorations are summarized in Table IV.

TABLE IV

SUMMARIZED LIST OF ARTICLES REVIEWED WITH THEIR RESEARCH GAP

ID	Article Reference	Year	Research Gap
PID1	[52]	2025	The absence of a national common language for representing public data, which impedes semantic interoperability.
PID2	[32]	2025	There are no general frameworks to address knowledge management comprehensively.
PID3	[61]	2025	To analyze trends in studies on cloud computing in e-government
PID4	[10]	2025	To explore the potential of Big Data analytics for public policy systems
PID5	[37]	2025	Integrates various technological and methodological approaches to improve service delivery and efficiency
PID6	[11]	2024	To identify the potential of AI and IoT to improve decision-making
PID7	[31]	2024	Focused on a lack of data standardization.
PID8	[2]	2024	Lack of collaboration and poor interoperability between varied vocabularies and formats.
PID9	[58]	2024	Lack of unified process models results in legal non-compliance and hinders information/service sharing.
PID10	[68]	2023	E-Government interoperability stems from discrepancies in data and system structures.
PID11	[9]	2023	To the use of social media and Web 2.0 technologies in government operations
PID12	[60]	2022	A lack of interoperability.

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PID13	[19]	2022	To find knowledge discovery and handle problems such as inductive reasoning, automatic classification, pattern recognition, learning algorithms, and data reduction
PID14	[38]	2022	Semantic interoperability specifically needs more focus on meta models or ontologies.
PID15	[12]	2022	Examines different proposed “ontology-centred techniques” to build security
PID16	[48]	2021	Explicit Link Discovery Scheme Optimized with Ontology
PID17	[65]	2021	To provide a comprehensive review of the existing literature on ontology in cloud computing
PID18	[14]	2021	There is a particular lack of vertical ontologies.
PID19	[55]	2021	Insufficient emphasis on the practical application of existing e-Government ontologies.
PID20	[66]	2021	Knowledge management within a heterogeneous database system.
PID21	[67]	2021	To find a collaborative e-governance model.
PID22	[51]	2021	To find a special knowledge base of government websites.
PID23	[33]	2020	A lack of accurate data repositories in e-government systems due to numerous, varied, and sometimes conflicting existing Information Systems.
PID24	[59]	2020	There is a lack of common and concretely defined Models for govcloud (government cloud computing).
PID25	[39]	2020	There is a need for a more robust and well-thought-out model that requires flexibility and ability to safeguard privacy, security and integrity of social information with a pragmatic information governance regime.
PID26	[13]	2020	To support the decision-making processes at the government level through reasoning and inference processes with ontology.

***Received**: April 25, 2026; **Revised**: May 4, 2026; **Accepted:** June 8, 2026; **Published:** June 15, 2026*
*Corresponding author- **Zelalem Getachew***

***ISSN** (E): 2959-3921*
(P): 2959-393X
***DOI:** https://doi.org/10.59122/EIJET1014*
Ethiopian International Journal of Engineering and Technology (EIJET)
Volume 4, Issue 1, 2026

PID27	[63]	2020	The proliferation of legal ontologies leads to interoperability problems because legal data from different countries/continents.
PID28	[49]	2020	Inconsistency and lack of interoperability between public systems.
PID29	[15]	2020	Effectively integrate ontology into existing systems and extend these approaches to real-world contexts.
PID30	[42]	2020	Establishing a common standard for interoperability in e-government services.
PID31	[3]	2020	The use of many technologies and methods for utilizing the semantic web and ontology in cloud computing and distributed systems.
PID32	[34]	2019	Allowing the explicit representation of legal context associated with government processes.
PID33	[35]	2019	Missing a standardized and comprehensive specification of cloud services.
PID34	[53]	2019	Lacking intelligence or having weaknesses in data handling.
PID35	[54]	2019	A need for an orchestrated design of smart city applications built upon strong theoretical foundations.
PID36	[40]	2019	The effectiveness of open data initiatives is hampered by data quality, sub-optimal methodologies/platforms, and limitations in generating actionable insights.
PID37	[57]	2019	Structural and semantic sharing of information and representation across heterogeneous organizations for applications and services.
PID38	[44]	2018	Suggested a pressing need for an ontology framework that can organize, structure, and describe the interlinked

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Volume 4, Issue 1, 2026

			concepts of regulatory requirements compliance within e-government system development.
PID39	[45]	2018	E-Government services face problems when systems use dynamic data structures and different queries.
PID40	[46]	2018	A significant increase in structured and unstructured webpages for electronic services, making repositories complex and difficult to analyze without semantic knowledge.
PID41	[36]	2018	A very limited published work specifically dedicated to defining Peace Engineering and ethical norms.
PID42	[62]	2018	Existing System of System meta-model research has not sufficiently emphasized the representation of complete System of System ontologies.
PID43	[23]	2018	Lacks the necessary precision for quality information.
PID44	[47]	2017	The integration of new technologies (such as Cloud, micro services, and IoT) and the combined use of Artificial Intelligence and ontologies in e-government are still limited
PID45	[30]	2017	There is a lack of prescriptive guidelines for ontology modularization.
PID46	[64]	2017	The multiplicity, scalability, and increasing difficulty in controlling descriptions and contents of data sources highlight the growing need for personalizing users' requests.
PID47	[50]	2017	How to effectively use existing ontology resources to achieve link discovery between different resources at the semantic level
PID48	[56]	2017	Building new ontologies from scratch is costly and time-consuming.

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PID49	[41]	2017	Here is a limited use of ontology-based methods for sentiment analysis.
PID50	[69]	2017	The formal language used may be inadequate; data may be insufficient for high-dimensional models.
PID51	[70]	2017	No single definitive and mature methodology for ontology engineering, with existing approaches primarily focusing on technical aspects.
PID52	[43]	2017	The integration of different process-related models in ontology Engineering.

V. DISCUSSION

As Table V indicates, to address the multidimensional issues and challenges of the current design and implementation of adaptive e-governance ontologies for proposing a cloud-based smart and trusted citizen-centric system, crucial attention and synthesis of the provided articles and analyses of the reviewed articles are necessary. This review article categorized issues into five sections based on the challenges and limitations observed in the prior research, reported, and considered in futuristic proposed solution models.

TABLE V

SUMMARY OF REVIEWED ARTICLES AND THEIR SPECIFIC ISSUES

S No.	Reference	Specific issues observed	No. of articles	In %
A.	[52][30][62][31] [51] [69][32][35][37][13]	Lack of a common national language or reference frameworks	10	19
B.	[60][45][58] [38][47][63] [49][55][57][44][23][9][12] [34][37][65][66][19][48]	Lack of semantic integration of data and interoperability	19	37
C.	[40][14] [59][68][70] [64][67][53] [11] [3][10]	Government process management solutions are limited at the semantic level	11	21
.	[15][41] [42][33][39]	Legal and policy barriers	5	10

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E.	[46][36][50] [2][43][54][56]	Lack of awareness and understanding of semantic web technologies	7	13

A. Lack of a Common National Language or Reference Frameworks Issues

This issue is part of a broader problem within the e-government sector where no universal standard for ontology is widely adopted. The authors [52] revealed that the lack of a common national language or standardized reference frameworks presents a significant challenge for semantic interoperability in e-government services, particularly in developing countries. Consequently, the study [52] noted that these issues may lead e-governance ontologies to heterogeneity that impedes semantic interoperability, contributes to a low maturity level for public e-services, and leads to the absence of effective collaboration and persistent interoperability issues. To overcome these challenges, the study[52] suggested that the implementation of a common vocabulary (CV) is considered crucial. Moreover, authors[13] emphasized that Ontology-based approaches are recognized as powerful tools for achieving semantic interoperability by providing formal, explicit representations of shared conceptualizations.

B. Lack of a Semantic Integration of Data and Interoperability Issues

This issue stems from disparate devices, systems, and applications using heterogeneous databases and different schema structure solutions related to interoperability in various digital environments, particularly within e-governance and emerging technologies (such as cloud computing, IoT) contexts. Several Studies[34] highlighted the critical role of ontologies and semantic web technologies in addressing issues of data heterogeneity, ambiguity, and inconsistency to enable effective information exchange and integration. Consequently, the studies[48],[49] discussed the challenges that organizations face, such as data redundancy, inconsistency, and difficulty in integrating, processing, and sharing information among agencies. The studies[64] proposed an integration of the semantic web, natural language processing (NLP) and ontology. Effectively addressing the persistent 'lack of semantic integration of data and interoperability issues' in smart environments, future research must focus on developing advanced, comprehensive, adaptive, and standardized approaches, heavily covering semantic technologies and ontologies. They help in bridging the gap between real-world data modeling and machine-interpretable representations, offering clearer relations and semantics through languages like OWL.

C. Government Process Management Solutions are Limited to the Semantic Level Issues

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(P): 2959-393X
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Ethiopian International Journal of Engineering and Technology (EIJET)
Volume 4, Issue 1, 2026

Government process management solutions are currently limited at the semantic level and often lack sufficient intelligence, hindering the effective delivery of e-government services. The studies [59],[53] argued that the inherent complexity of cloud computing itself contributes to confusion in defining specific governmental cloud use cases, leaving implementation, management, and governance inadequately defined without more specialized taxonomies. Further, the authors [64] Noticed the upcoming e-governance designs should be tailored to "Government 3.0" with customized and intelligent services powered by Semantic Web technologies, the effective integration of ontologies into summarized that this deficiency leads to systems that cannot classify users based on their interests or deliver personalized results, often providing uniform information regardless of individual preferences or query context. Existing e-government personalization frameworks are noted for their lack of intelligence and weaknesses in data handling, thereby restricting the adoption and widespread use of new services in many countries, and often failing to achieve their intended benefits. To sum up, the studies[53],[11],[3],[10] recognized that the current research efforts need to progress towards future government paradigms such as existing legacy systems and real-world e-government contexts, which remain a critical, ongoing research gap.

D. Legal and Policy Barriers Issues

Legal and policy frameworks profoundly influence the development of e-government services by providing the foundational rules, shaping design parameters, dictating operational compliance, and guiding their evolution [15]. To the contrary, the authors [42] elevate that the absence of comprehensive legal modeling has been linked to the failure of innovation pilots, underscoring the necessity for the concurrent growth of Technological, Societal, Organizational, and Legal Readiness Levels for successful digital public service provision. To overcome these barriers, researchers in a study [42] proposed development of formal models, such as Legal Readiness Levels (LRL), to assess compliance and the transformative power of legal systems in innovation, particularly for public sector services that are obligated to comply with existing laws.

E. Lack of Awareness and Understanding of the Semantic Web Technologies Issues

The lack of awareness and understanding of semantic web technologies presents several issues in the development and implementation of ontologies, as highlighted in the study sources. The following reasons are drawn as pinpoints: Complexity and Tediousness of Ontology

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Development[46], Lack of, and Limited Adoption and Unexploited Potential [2],[50]. Further, the studies [36] [2] identified that there is also an unexploited synergy between Knowledge Management (KM) and ontology in various aspects of e-governance.

VI. CONCLUSIONS

The sources highlighted that significant hurdles and challenges remain in the transition from traditional e-governance to smart, cloud-based, and citizen-centric ecosystems which represent a pivotal paradigm shift toward more data-driven and personalized public service delivery. Meanwhile, the convergence of cloud computing, intelligent systems, and semantic web technologies offers transformative potential for adaptive, interoperable, intelligent, scalable, efficient, and cost-effective, and citizen-centric services.

Ultimately, the goal of a smart, intelligent e-governance system is to deliver citizen-centric services, which prioritize user needs by improving responsiveness, personalization, and fostering citizen engagement in decision-making processes through accessible and user-friendly interfaces. By leveraging intelligent technologies such as AI and machine learning within an e-governance ontological framework, governments can foster greater trust, transparency, and accountability while ensuring governance services are accessible "anywhere and anytime" to the citizens.

This systematic literature review highlights that e-governance ontologies are essential for establishing a common knowledge base and achieving the semantic interoperability required to integrate heterogeneous data sources within government domains. Despite its relevance, smart governance is still an incipient field, facing a lack of comprehensive implementation frameworks. Ontology development needs to be tailored to specific localized contexts while overcoming the technical, legal, policy, and social complexities of digital transformation. In conclusion, the current trends highlight that designing an e-governance ontology is like creating a universal translator for a city where every neighbourhood speaks a different dialect, i.e., unity in diversity; it does more than just facilitate conversation, and it allows the entire infrastructure to work together as one cohesive responsive unit.

To realize this potential, future research must prioritize the convergence of e-governance ontologies with cloud computing, intelligence in systems and semantic web technologies; to build robust, smart, and citizen-centric e-governance ecosystems. Addressing the ongoing challenges

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related to semantic interoperability, cloud security, and the comprehensive implementation of smart governance frameworks remains critical for realizing the full potential of these digital transformations.

Future work should focus on developing specific modeling methods for ontology-oriented entities, fully implementing and validating proposed solutions in real-world scenarios, and continuing to explore the scalability, reliability and adaptability of these architectures to handle growing data volumes and evolving user or citizen demands efficiently. The proposed ontologies can be more specific for the developing countries having similar governance structures and cultures to customize and adopt in the e-governance systems transformations.

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Received*: April 25, 2026;* ***Revised****: May 4, 2026;* ***Accepted:*** *June 8, 2026;* ***Published:*** *June 15, 2026*
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***Received**: April 25, 2026;* ***Revised**: May 4, 2026;* ***Accepted:** June 8, 2026;* ***Published:** June 15, 2026*
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