

Original Article

Towards Sustainable Rural Digital Governance: Global Enterprise Architecture Practices and an Integrated e-Panchayat Framework for India

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Abstract - The analogous rapid growth of digital governance and Enterprise Architecture (EA) have had a profound impact on the global public governance systems, particularly in terms of their operations. The e-Panchayat Mission Mode Project is an integrated digital rural governance ecosystem, designed to enable digital interventions for planning, financial management, monitoring, online auditing and the delivery of transparent online services at the grassroots level in rural India. This study examines the current trends and practices of EA and analyses its effects on the sustainable rural governance in the context of e-Panchayat systems in India. A qualitative systematic literature review approach has been done to evaluate Enterprise Architecture frameworks and digital governance models correlating interoperability mechanisms, ICT governance and decentralized rural governance systems. Furthermore, this study assesses the e-Panchayat ecosystem in India with regards to its integrated citizen-centric governance in the rural areas. The results indicate the importance of Enterprise Architecture in enhancing the interoperability, integration and participatory governance of the sustainability dimension within decentralized administrative systems. Drawing the correlation, a conceptual Enterprise Architecture-driven framework has been proposed, aiming to achieve a sustainable and interoperable digital governance system in rural local government encompassing 0.27 million Panchayati Raj Institutions in India.

Keywords - Digital Governance, Enterprise Architecture, E-Panchayat, Interoperability, Rural Governance.

1. Introduction

The fast growth of Information and Communication Technologies (ICTs) over time has impacted governance processes everywhere, and has brought about a paradigm shift that has not been witnessed in governance systems before - a shift from traditional governance systems to digitally empowered governance ecosystems. As governments see the potential of digital technologies to bring efficiencies in the administration, transparency, accountability, interoperability and citizen engagement in public service delivery, they are increasingly implementing them in their operations [1-3].

The transition from the classic e-Government programs, which mainly aimed at making public services digital, towards the view of digital governance and a broader digital governance paradigm, which puts emphasis on integrating the governance process, responding to governing with data, interoperability among platforms, citizen-centric governance and development issues has been a gradual process [4, 5].

More demands are emerging for the use of responsive, participatory and transparent governance systems to meet complex socio-economic and developmental issues have further speeded up digital governance's tempo. Governments have learned over the past few years that digital programs that are implemented in small, isolated projects are not sufficient to address today's government demands for effective governance. Hence, some countries have decided to adopt an integrated governance model employing Enterprise Architecture (EA) support to coordinate between the different government departments, agencies and public-sector entities [6-8]. In the last several years, EA has emerged as a strategic governance tool to help organizations align themselves, their business processes, information systems, data resources and technological infrastructure [9, 10]. The Government can create interoperable digital ecosystems that facilitate the implementation of policies, the use of resources and public services in an efficient way through standardized architecture frameworks, while gaining benefits in the process [1, 11].



The use of Enterprise Architecture in Governance has evolved into a worldwide trend. In a few countries, the National/Government-wide Enterprise Architecture (NGEA) frameworks are still under development to modernize the government and to support integrated digital governance, such as in the United States, South Korea, Singapore, Malaysia, Bangladesh and India [3-14]. The United States Federal Enterprise Architecture Framework (FEAF), Government-wide Enterprise Architecture initiatives (GEA) in South Korea and the Malaysian Government Enterprise Architecture (MyGovEA) model provide example applications of how a governance approach based on the enterprise architecture can enhance interoperability, transparency, and citizen-centric service delivery [6, 13-15]. Similarly, India Enterprise Architecture (IndEA) has been developed to facilitate the vision of “ONE Government”, building a single foundation and interoperability in the governance between ministries and departments under the ideas and principles of Enterprise Architecture [7, 16].

At the same time, there has been a rising ‘global governance discourse’ with sustainability as the top objective of digital transformation initiatives. Despite being a relatively new and emerging field, digital governance has emerged as a field of interest for the realization of Sustainable Development Goals (SDGs) due to its great promises in terms of efficiency in government, citizen participation, access to services and evidence-based policy making [4, 17, 56]. Recent research has shown that it can make a difference for SDGs; digital governance frameworks can help increase transparency, decrease corruption, increase administrative efficiency, increase institutional accountability and optimize use of resources [2, 3, 5]. In addition, recent research has highlighted the potential for new technologies, such as Artificial Intelligence (AI), big data analytics, Internet of Things (IoT), and cloud-based governance systems to be integrated with energy systems to achieve new benefits for energy efficiency, environmental sustainability and smart resource management [18].

2. Background, Literature Review, and Research Context

2.1. Digital Transformation and Governance Initiatives in Rural India

While there have been great strides in digital governance globally, there are still tremendous obstacles to the benefits these offer to rural and decentralized governance systems, especially in developing countries. Digital issues regarding digital infrastructure, interoperability, technical capacity, financial resources, digital literacy, and institutional coordination are some of the limitations often faced by rural governance institutions [19-21]. These are increasingly important in the rural-dominated countries with a decentralized administrative system like India. The Panchayati Raj system was introduced by the 73rd

Constitutional Amendment Act, which is one of the largest decentralized systems of governance in the world, with the village, intermediate and district levels of governance [22]. A strong push for the digitalisation of Panchayat Raj Institutions (PRIs) is thus a key demand for inclusive rural development, participatory governance and sustainable local governance as a whole.

To tackle these issues, the Government of India has adopted various digital governance programmes that focus on digitizing the governance process of rural governance and operational efficiency of around 0.27 million Panchayati Raj Institutions, the backbone of rural local government in India. Under the umbrella of e-Panchayat Mission Mode Project (MMP), the digital platforms like Panchayat Enterprise Suite (PES), eGramSwaraj platform, AuditOnline system, Gram Manchitra and GeoMGNREGA represent such a radical leap towards the formation of a digital rural governance ecosystem [23-36]. All of these platforms enable digital planning, financial management, spatial planning, online monitoring and auditing, participatory planning and transparent service delivery at the grassroots level. Further, the eGramSwaraj and its integration with the Public Financial Management System (PFMS) have helped in bringing greater transparency and financial accountability in real-time governance of Panchayats [23, 24, 37]. Moreover, with the rise of popularizing GIS in rural planning and governance, it is found that GIS-based platforms for governance are becoming more and more vital in rural sustainable planning, like Gram Manchitra and GeoMGNREGA [32-35].

However, there are still a number of problems in implementing sustainable and integrated digital governance at the Panchayat level. The current systems are often fragmented and have low interoperability levels between governance platforms, a low level of architecture standardization, a lack of governance maturity and different levels of digital readiness in rural areas [19, 20, 38]. Furthermore, the governance programs in place often focus on the deployment of technologies without taking into account the sustainability, citizens' involvement, the integration of governance, and the maturity of the EA. Available literature also indicates the lack of comprehensive EA models that are specific to sustainable rural governance and e-Panchayat ecology [1, 4].

Hence, it is necessary to critically assess the practices of EA and the digital governance models in the global scenario and draw insights that would be relevant for a sustainable governance system for the rural areas in India. Learning from the existing international bodies on governance-related issues, such as interoperability, transparency, citizen-centricity, sustainability, ICT governance and digital inclusion, can offer good lessons for enhancing the e-Panchayat ecosystem in India. From this perspective, the current study seeks to explore the global scenario and practices of Enterprise Architecture (EA) in Governance and their relevance to develop sustainable

governance and e-Panchayat in India. The study also aims to integrate and synthesize the existing literature to present a concept of how the support of Enterprise Architecture can be applied to the sustainable, transparent, participatory and integrated digital governance ecosystems at the grassroots.

Overall, the trend in governance transformation from using traditional administrative systems to building sustainable and citizen-centered digital governance ecosystems can be seen in Figure 1.

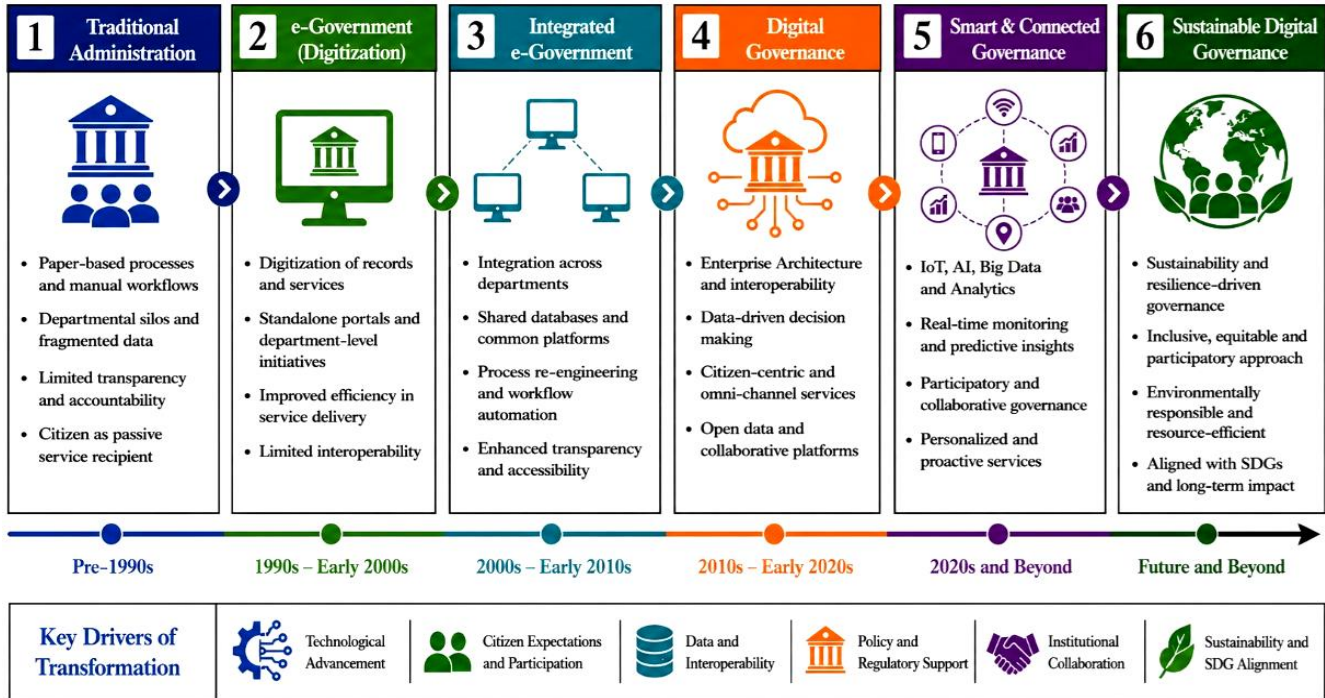


Fig. 1 Evolution of governance transformation: From traditional administration to sustainable digital governance

Increased complexity of modern governance systems and new developments of digital technologies have greatly heightened the demand for integrated, interoperable and citizen-centric governance systems. Large-scale organizational administrative operations between multiple agencies, heterogeneous information systems, a large volume of data resources and different public service delivery mechanisms have forced governments across the globe to adopt new policies of handling the operations. In this setting, digital projects and governance structures are often fragmented, resulting in efforts duplication, inefficient use of resources, lack of data sharing, interoperability problems or effectiveness of governance measures [1, 6]. As a result, EA has become a strategic governance approach that can meet these challenges by allowing for the comprehensive alignment of the organizational goals, governance processes, information systems and technological infrastructures.

2.2. Enterprise Architecture in Governance

Enterprise Architecture largely states to a structured framework that describes the organizational structure, business processes, information flows, applications, technologies, and governance mechanisms of an enterprise in an integrated manner [9, 39, 40]. In the corporate world, EA is employed to facilitate an organisation's change and facilitate

the alignment of the IT and business. Correspondingly, EA is also slowly gaining ground as one of the keys to enabling the public sector modernization or digital transformation [6, 14]. In governance, EA can be used not only to standardize technologies but also to plan strategies, coordinate administration, manage interoperability, and access policies and citizen-centric service delivery [1, 11].

Most of the impetus for EA in the governance realm is to establish “whole-of-government” forum(s) where the ministries, departments, agencies and local government units collaborate effectively. In many of the traditional governance models, there are a series of administrative systems in silos, i.e. separate departments develop their own database and/or digital solutions to work on [1, 41], and no governance or interoperability standards exist.

This fragmentation leads to a lack of information to be shared, lower operational efficiency and complications in the delivery of services to the citizens. Enterprise Architecture frameworks alleviate such challenges by establishing a set of principles, governance structures and interoperable digital ecosystems in the form of standards to help integrate across agencies for collaborative governance [6, 7, 11].

There are multiple world-renowned Enterprise Architecture frames which have been pivotal to the governance change. One of these is particularly relevant, The Open Group Architecture Framework (TOGAF) [9, 10], which offers a structured means to develop enterprise architecture via a series of processes called the Architecture Development Method (ADM). TOGAF can be applied to relate Governance to Business Architecture, Data Architecture, Application Architecture and Technology Architecture. The other facets of the governance framework are: Governance maturity, Architecture repositories, Stakeholder management and Continuous organizational change [9].

In a similar manner, the Federal Enterprise Architecture Framework (FEAF), which was developed by the United States Government, is one of the first enterprise-level uses of EA in public service [6]. FEAF was created to solve problems with interoperability and redundant systems, to improve collaborative governance and to promote strategic alignment between the different Federal agencies. Also, there is a framework of a set of reference models that can be used to standardize the governance and establish a uniform operation in the Public Sector [6, 41], such as the Business Reference Model (BRM), the Data Reference Model (DRM), the Service Reference Model (SRM) and the Application Reference Model (ARM). A very influential model that has had an impact on several countries' government-wide Enterprise Architecture models is the FEAF model.

Over the last few years, some countries have started to have their own Enterprise Architecture initiatives on a national level, based on national governance needs. The Government-wide Enterprise Architecture (GEA) of South Korea is a very successful integrated digital governance model based on interoperability and standardization, and citizen-centric with a centralization of the public-sector Information and Communication Technology (ICT) resources [13, 15]. Singapore has also embraced Enterprise Architecture (EA) principles to reinforce integrated governance, enhance public service efficiency and to facilitate the digital public administration [8]. Malaysia Government Enterprise Architecture (MyGovEA) is another good example of an architecture-driven governance transformation that consists of a set of public sector-specific standards like business, data, application and technology reference models [14].

India saw the need to have its own national enterprise architecture framework, given the global trends and the strategic role of Enterprise Architecture in transforming governance, which is known as India Enterprise Architecture (IndEA) [7, 16]. IndEA will help develop a consolidated and interoperable governance approach that will make seamless coordination between government agencies possible and drive the vision of "ONE Government". The integrated service delivery, shared digital infrastructure, uniformed data

governance, interoperability and citizen-centric governance systems are among some of the features of the framework [7].

The main advantage of Enterprise Architecture from a Governance perspective is to enable the interoperability capabilities between Governance solutions. Interoperability can be defined as the ability of several information systems, applications and organizations to communicate and cooperate to exchange data [1, 11]. Interoperability is an important precondition for providing integrated services, coordinating the creation of policies, sharing data in real time and administrative decision-making in digital governance.

The other key element of Enterprise Architecture in governance is to add transparency, accountability and efficiency to governance. In recent years, there has been an increasing emphasis on the importance of data-driven decision-making, electronic audit, monitoring and integrated financial management systems in modern governance systems. The governance platforms can be structured in EA frameworks, and these can be intertwined in one governance ecosystem [42, 43].

EA is also becoming more and more an enabler of sustainable Digital Governance. The new governance contexts involve the use of new digital technologies such as Artificial Intelligence (AI), Cloud Computing, Big Data Analytics, Internet of Things (IoT) and Geographic Information Systems (GIS) in the public sector [4, 8]. In addition, Enterprise Architecture has the ability to relate any digital transformation project with Sustainable Development Goals (SDGs) and with sustainable development and citizen-oriented governance objectives [4, 5].

However, there are a couple of concerns with respect to the implementation of Enterprise Architecture (EA) in governance. In less developed countries, institutional capacity, the maturity of the governance, digital infrastructure, policy coordination, technical expertise, as well as financial constraints and resistance to organizational change are a few challenges often faced in EA implementations [19, 21, 45]. Furthermore, not all governance systems are homogeneous, nor are there any integrated governance models suitable for decentralized rural governance systems. This is relevant especially in the context of the digital governance maturity and interoperability of the rural governance systems and e-Panchayat ecosystem in India.

Hence, it is crucial to be aware of the most common EA practice and governance transformation models implemented in different regions of the world, to create sustainable integrated models of governance in rural areas. Enterprise Architecture could be utilized as a strategy towards the achievement of multi-agency interoperability, an integrated governance platform, participatory governance, GIS-enabled planning, transparency and citizens-centric rural service

delivery of e-Panchayat systems. With this in mind, the growth path of EA in governance suggests some notion and provides a hint to ponder upon the impact of EA on Sustainable rural governance and the 'Digital Panchayat'

ecosystem of India. The enterprise architecture's conceptual representation of the digital governance ecosystems that can be supported, which are integrated, interoperable, transparent and sustainable, is shown in Figure 2.

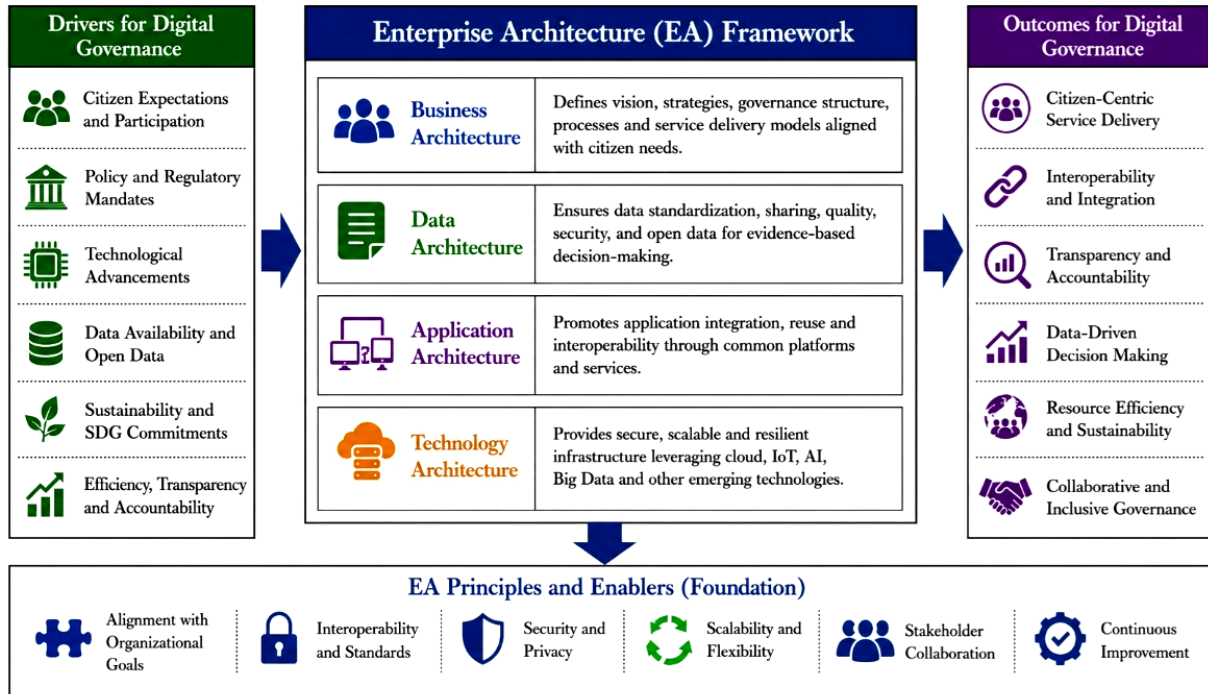


Fig. 2 Role of enterprise architecture in enabling integrated, interoperable, and sustainable digital governance

2.3. Sustainable Rural Governance and the e-Panchayat Ecosystem in India

The governance of rural areas is very much part of the governance and development of India, with its huge rural population, socioeconomic diversity and decentralized governance. The Panchayati Raj system, with the Constitution of India having elevated the system of Panchayati Raj into a three-tiered local governance system through the 73rd Constitutional Amendment Act of 1992, has introduced a three-tier arrangement of Gram Panchayat at the village level, Panchayat Samiti at the intermediate level and Zila Parishad at the district level [22]. The principal objective of this decentralized governance is to improve grassroots governance, contribute to the enhancement of grassroots development planning and to ensure localized implementation of development programs [22, 29]. Over the years, Panchayati Raj Institutions (PRIs) have been developing into vital instruments of governance at the local level, and for rural infrastructure development, welfare and social justice and citizen participation in governance processes.

Although the Panchayati Raj Institutions are of institutional significance, in India, the rural governance system has always been plagued by structural and operational challenges. These include administrative fragmentation, lack of coordination among departments, lack of financial

transparency, ineffective service delivery, poor monitoring, lack of citizen participation, lack of data integration and lack of infrastructural capacity [19, 38]. Furthermore, there are disparities in the capacity to establish effective governance systems among rural areas, given variations in digital infrastructure, governance capacity, technical expertise and financial resources [20, 21]. The limitations have often prevented the effective reactions of the local governance institutions to new development challenges concerning sustainability, digital inclusion, transparency and participative governance.

Digital governance has created new possibilities for the use of Information and Communication Technologies (ICTs) in public administration to radically change the rural governance systems. The Government of India has initiated multiple efforts in the area of decentralized administration for the modernization of the Panchayat Raj Institutions and to enable better governance at the grassroot level by adopting digital initiatives like e-Governance and digital rural governance. One of the most critical projects in this direction is the e-Panchayat Mission Mode Project (MMP) under the National e-Governance Plan (NeGP), which will help in digitizing and integrated management of functions related to Panchayat governance [23, 25, 27].

The e-Panchayat aims to create a digital governance ecosystem for Panchayat Raj Institutions, which integrates planning, budgeting, accounting, monitoring and auditing, asset management, and spatial planning with citizen service delivery functions into interoperable digital platforms [25, 27]. The program is a significant step towards moving from existing paper-based governance to governance enabled by digital technologies, which could help to enable transparency, accountability, and efficiency and citizens' participation in rural governance [48]. The e-Panchayat initiative has been successful to develop the Panchayat Enterprise Suite (PES) of various integrated applications for various governance activities at the Panchayat level [27]. All these applications are part of a decentralized planning, online financial management, the delivery of services, social auditing, the reporting of governance and its monitoring.

eGramSwaraj is one of the most significant integrated digital governance applications for PRIs, among the various digital governance platforms launched in the e-Panchayat environment. eGramSwaraj is an enabling platform which can be integrated with Public Financial Management System (PFMS) 23-24 and 25 for digital planning, accounting, asset management, monitoring of work done and online payments. Gram Panchayats can design Gram Panchayat Development Plans (GPDPs), monitor their development process, maintain a log of all financial transactions, and have a transparent online payment mechanism [23, 37]. The latest Government data shows that eGramSwaraj is a gold standard in the field of digital planning and financial management among gram panchayats in India, with a majority of panchayats adopting it [37].

One of the noteworthy milestones achieved in the whole process of eGramSwaraj will lead to financial transparency and financial accountability in the governance system of Panchayats when it is linked with PFMS. Using real-time digital fund management and online payment processes, the platform helps to avoid delays in administration, procedural inefficiencies, and improve transparency in financial management in rural areas [23- 24, 37]. Similarly, the online audit platform Audit Online has been launched, which will improve the accountability of online audit and governance processes, enabling online audit management and monitoring of the financial activities of Panchayats [31]. The different types of digital governance systems all help to facilitate more effective governance in the decentralized governance ecosystems.

The other significant challenge is the increased adoption of GIS-based governance and spatial decision-support systems in the countryside in India. The other key dimension of the rural digital governance transformation in India is the increased use of GIS-based governance and spatial decision-support systems. Spatial planning, geographical mapping of infrastructure, resources monitoring and decision making

should be crucial factors to achieve sustainable rural governance. The Government of India, in this context, has initiated platforms such as Gram Manchitra and GeoMGNREGA, introducing Geographic Information Systems (GIS) in Panchayat governance [32-35]. Gram Manchitra is a spatial planning and decision support system to envision and monitor the resources, infrastructure and assets of the villages through a geospatial mapping system, which assists Panchayats to perform this task [34, 35]. Similarly, GeoMGNREGA helps in geotagging and spatial monitoring of rural developmental assets created under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) [32, 33].

GIS technologies in Panchayats are a positive initiative in the direction of Sustainable and evidence-based rural planning. GIS-based governance systems provide better monitoring of rural infrastructure, better resource allocation, efficient developmental planning, and greater transparency in the implementation of projects [32-35]. These systems also allow for data-driven governance and spatial analytics to support the development of Panchayati Raj Institutions and their ability to align these plans with sustainability objectives and local governance priorities.

Sustainable rural governance also needs to have participatory governance mechanisms that have the capacity to engage citizens, local communities and stakeholders in governance processes. In this context, Gram Panchayat Development Plans (GPDPs) have come into existence as a participatory planning tool at the local level in India [29, 46]. The aim of GPDPs is to integrate priorities, citizens participation and community-based development planning in the Panchayats governance system.

The Ministry of Panchayati Raj has emphasised the importance of improving the quality, inclusiveness and effectiveness of GPDP processes to ensure the goals of Sustainable Development [SDGs] and strengthen grassroots governance [46]. The use of digital governance platforms such as eGramSwaraj, which enable online planning, monitoring, reporting and participation of citizens, is also in support of participative governance [25].

Even though there have been a lot of advancements in digital governance in rural areas, there are some implementation challenges that hinder the effectiveness and sustainability of e-Panchayat systems in India. The studies reveal that the problems related to digital infrastructure, digital literacy, technical skills, lack of training, financial constraints, interoperability and capacity of rural governance systems across regions still exist in rural governance systems [19, 20, 38]. Rural and marginalized communities sometimes face connectivity problems, infrastructure limitations and sociocultural obstacles, which limit access to digital governance services [20]. Moreover, a number of the

governance systems in Panchayats are yet to be operational in a comprehensive fashion with no integrated EA systems or support for seamless interoperability between the governance platforms and departments [1, 38].

Another critical challenge that needs to be addressed is the governance maturity and coordination of institutions in decentralized governance structures. To implement digital governance, it needs to be technologically ready as well as institutionally ready, to have uniformity of governance, administrative coordination, cybersecurity structures and sustainable governance models [21, 42]. Furthermore, the governance structures that are currently in place are mainly oriented towards operational digitization without considering other governance elements such as sustainability integration, data governance, participatory governance maturity or long-term governance interoperability [4, 5].

Sustainable rural development and governance modernization have been a key focus area of the Government of India in recent years, with a thrust towards digitalization. The policy vision expressed in the initiatives such as Digital India, Rashtriya Gram Swaraj Abhiyan (RGSA), e-Panchayat MMP, GIS-enabled rural governance platforms, etc., indicates the efforts towards PRIs as a digitally empowered, transparent, participatory and citizen-centric governance system. However, the implementation of the principles of EA, interoperability frameworks, governance standardization processes and the digital inclusion strategies and governance models for sustainability must be more holistic to ensure sustainable rural governance.

Therefore, it is important to have an understanding of the evolving of e-Panchayat systems and sustainable governance in rural India prior to studying how EA can support the integrated digital governance systems at the grassroot level in India. The path to realize Panchayat Raj Institutions as citizen-friendly digital governance systems that are interoperable, sustainable and inclusive for rural development remains crucial in India for the realization of inclusive, transparent governance and long-term sustainability objectives in India.

2.4. Research Context and Problem Definition

A sea of changes has taken place in public administration systems around the world as a result of the development of digital technologies and the modernization of public administration. Using Enterprise Architecture (EA), digital governance frameworks, and interoperable information systems and digital governance platforms, based on Information and Communication Technologies (ICT), is becoming popular among governments for better and more efficient service delivery, government transparency and public participation [1, 6, 4]. There has already been a substantial number of works undertaken on the national and urban level with regard to digital governance, but decentralized and rural governance systems are undergoing a transformation, which is

not always even and complete, particularly in developing countries [19, 21, 45]. This is especially significant in the realm of sustainable rural development and provision of welfare services in a nation such as India, where the governance structure in rural areas is mostly determined by the governance structure of the rural areas.

India owns the largest decentralized governance systems in the world through the Panchayati Raj framework, having three levels of governance: local level in the village, intermediate level and district level [22]. The Government of India has recently taken several measures for the modernization of the governance system of Panchayats, through applications like Panchayat Enterprise Suite (PES), eGramSwaraj, integration with PFMS, Audit Online, Gram Manchitra and GeoMGNREGA under the e-Panchayat Mission Mode Project (MMP) [23-36]. This is a good step forward towards the development of digitally empowered and local governance eco-systems. However, there are still challenges in terms of structure, technology, administration and institution to overcome to achieve sustainable and integrated digital governance at the grassroots.

Fragmentation of governance platforms, lack of comprehensive interoperability mechanisms are among the main challenges in the digital governance system of rural areas. There are many governance structures that are independent, and do not have good integration between the planning, financial management, auditing, spatial governance and citizen service delivery platforms [1, 38]. This in turn contributes to the barriers, fragmentation and inefficient information sharing process, which further makes governance complicated and inefficient and a lack of sufficient integration of decision-making processes. The elaborately developed platforms like eGramSwaraj, PFMS, Audit Online and Gram Manchitra have strengthened governance in Digital governance, but there are limited efforts towards architectural integration of all these platforms to create a governance platform within the Panchayati Raj Institutions [23-35].

The other challenge is the lack of implementation and development of the principles of EA in a decentralized rural government system. Governance activities are being undertaken that are more oriented towards the digitization of governance activities, rather than building an integrated architecture-driven governance ecosystem [19, 38]. The standard frameworks like FEAF, TOGAF and IndEA are well-developed and applicable to the governance of Panchayats, but not so in the context of coordinated digital transformation of Panchayats [6-7, 9]. Consequently, very few governance systems are available in rural areas that have formal governance structures, and the transfer of governance systems to a digitized and sustainable environment is restricted in terms of scalability, interoperability, security and sustainability.

However, there are governance inequalities in sustainable systems of digital governance in rural areas, too - not just the digital divide. Some of the challenges faced were poor digital infrastructure, unstable Internet, low digital literacy, lack of digital technical training, and lack of accessibility of digital governance services by the marginalized and rural communities [19-21]. They restrict the citizens' engagement, reduce the inclusiveness of governance and weaken the working of governance using ICT in the rural areas. Studies have further highlighted that the governance change without technology is not working as long as the change is also supported by an institutional capacity development process, engagement of stakeholders, policy support and governance readiness [47].

Moreover, there is a lack of few existing governance models that take into account of the sustainability of rural digital governance. The link between digital governance and Sustainable Development Goals (SDGs) is increasingly recognized; however, a governance system that has yet to become sustainability-oriented, and develop a sustainability-oriented governance architecture and has not yet developed to support environmental sustainability, resource efficiency, inclusive governance and long-term governance resilience [4, 5].

Furthermore, many governance systems are still going through the process of digitalizing governance and are not focusing on sustainability issues such as energy consumption, space-based governance, collaboration and participation, environmental monitoring or sustainable resource management [18].

Other challenges in the rural digital governance systems include: a lack of a holistic governance maturity framework, and a lack of an ICT governance mechanism. Important enablers and supports for good governance transformation include designing good ICT governance systems, cybersecurity systems, governance assessment systems, transparency systems and institutional coordination systems [42-44].

The governance preparedness of the Panchayati Raj Institutions, however, is not uniform, with variation in terms of governance preparedness, availability of funds, administrative capacities and technological infrastructure of the Institutions [19, 38]. These differences impact how digital government is implemented in various rural locations, the quality and effectiveness of digital government and its sustainability.

The involvement of citizens, participatory planning and trust in the governance institutions and transparency in the decision-making process are essential to develop a sustainable governance system [45, 48-49]. While digital governance platforms can assist in improving participatory governance

and citizen-centric administrations, the low awareness of citizens and their communities of the platforms, low digital access, sociocultural barriers and weak mechanisms of citizen participation in governance are still challenges in rural governance systems [20, 50, 51]. In reality, the majority of the digital governance programmes are not participatory and citizen-centric, but rather geared towards administration.

GIS-based planning, spatial analysis, geo tagging and evidence-based infrastructure mapping and policy implementation have come to be a major part of sustainable rural governance [32-35]. It is noteworthy that the governance process, for the first time, adopted the concept of geospatial in platforms like Gram Manchitra and GeoMGNREGA, but not in governance and decision-making. The lack of education and awareness of the importance of spatial intelligence as a planning and management tool for sustainable development is one of the main challenges of PRIs in the use of this important tool.

Furthermore, literature reveals that there exist research gaps associated with Enterprise Architecture and sustainable rural governance. While there are ample existing studies on EA at the national and organizational level [6, 7, 9], digital governance and public value [3], sustainability-oriented governance [4], and e-government implementation challenges [19], there is limited research on the application of EA in sustainable rural governance ecosystems and e-Panchayat. The latter is more the case with integrated conceptual frameworks, which systemically connect the concepts of Enterprise Architecture, interoperability, sustainability, participatory governance, GIS-enabled governance and digital inclusion, in decentralized governance environments.

Therefore, the core research problem addressed in this study is the absence of a comprehensive framework to support an integrated, interoperable, transparent, participatory and sustainable rural digital governance system in the context of the Indian e-Panchayat ecosystem with the help of Enterprise Architecture. This has to be addressed by analyzing the experience of global EA practices, digital governance systems, sustainability-oriented governance systems and rural governance transformation systems, and learning from them and transferring the concepts to decentralized governance systems in India.

Considering the above, the present study is developed to systematically analyzing the existing research and EA practices in the governance and its linkage with sustainable rural governance and e-Panchayat ecosystems in India. The study further aims to blend existing knowledge to propose an integrated conceptual understanding of how Enterprise Architecture can strengthen digital Panchayat governance through improved interoperability, governance integration, sustainability alignment, citizen participation, and spatially enabled governance systems.

2.5. Research Objectives, Scope, and Contributions

The prime objective of the study is to discuss about the global trend and practices of the Enterprise Architecture (EA) and its impact on the sustainable governance of rural areas and the e-Panchayat system of India in the governance context. This study focuses on the possibilities for implementing EA to develop integrated, interoperable, transparent and citizen-centred digital governance ecosystems [1, 4, 6, 7]. It also introduces the most relevant international governance frameworks and digital governance processes to draw out strategies that could be relevant for the decentralized rural governance system.

This study also brings in the concept of digital governance and Enterprise Architecture for the sustainability, governance efficiency, transparency, accountability and citizen participation [2-5]. The e-Panchayat ecosystem and the various other platforms, such as eGramSwaraj, Panchayat Enterprise Suite (PES), Audit Online, Gram Manchitra, and GeoMGNREGA [23-36], are getting highlighted for digital rural governance and decentralized governance. Further, some of the challenges identified in sustainable digital governance in rural India are also identified in the study, such as challenges on interoperability, governance fragmentation, digital divide, digital governance maturity gap and infrastructural issues [19-21, 38].

The following are some of the important research questions that will be focused on in this study:

- How are Enterprise Architecture frameworks being utilized globally for governance transformation and digital public administration?
- What role does Enterprise Architecture play in promoting interoperability, transparency, sustainability, and citizen-centric governance?
- What are the major challenges affecting sustainable rural digital governance and e-Panchayat systems in India?
- How can Enterprise Architecture support integrated, interoperable, and sustainable e-Panchayat governance ecosystems?

The various aspects of the Enterprise Architecture (EA) framework, digital governance systems, interoperability, governance for sustainability and ICT governance and decentralized rural governance systems are the focus of the study with special emphasis on 'e-Panchayat' in India [1, 3, 4, 6, 7, 23-35]. However, if all analyzed from the same perspective, it could help to explain the concepts of Enterprise Architecture, digital governance in a sustainable way and the concept of rural governance.

The study contributes by integrating Enterprise Architecture, sustainable digital governance, and rural governance within a unified analytical perspective. Based on

the synthesized literature and governance analysis, the study further proposes a conceptual Enterprise Architecture-driven framework for strengthening sustainable, interoperable, transparent, and citizen-centric e-Panchayat governance systems in India [4-7].

2.6. Structure of the Paper

The rest of the paper has been outlined as follows. Section 3 introduces the conceptual foundations and theory concerning Enterprise Architecture, digital governance, sustainability-oriented governance, interoperability and rural governance systems. The research methodology, which was followed for this study, including the review methodology, literature sources, inclusion criteria, thematic classification and analytical framework, is outlined in Section 4. The theories and implications are covered in Section 5, which discusses the various global trends and practices of EA in governance, major global digital governance models, governance transformation with a reference to EA, analysis of the role of EA in sustainable rural governance, e-Panchayat eco-system in India, digital transformation, GIS governance, participatory governance, digital inclusion, and alignment with sustainable governance. Section 6 proposes a conceptual Enterprise Architecture-based framework for sustainable and interoperable e-Panchayat governance and gives policy recommendations and a roadmap for its implementation. Lastly, Section 7 reviews the key research gaps, future research directions and concluding comments of this study.

3. Conceptual Foundations and Theoretical Background

The theories that form the basis for the current research are that the concepts of Enterprise Architecture (EA) and digital governance, sustainability-oriented governance and decentralized rural governance systems are related [4, 6, 7]. The section highlights the important concepts on enterprise architecture, interoperability, ICT governance, citizen-centric governance and e-Panchayat systems, to understand their relevance for the sustainable and integrated rural digital governance in India [23-35].

3.1. Enterprise Architecture: Concepts, Evolution, and Governance

Enterprise Architecture (EA) is a framework that allows coordinating the organization's vision, business processes, information systems, data resources and technological infrastructure under a common governance [39, 40]. The EA has become more and more a tool to modernize the public sector and provide IT-business alignment [6, 14] to help enterprise transformation towards a digital governance in the management of organizations. The roles of EA in the governance systems are: interoperability of systems, effective and coordinated governance, integrated service offerings, standardization and efficient use of resources [1,7].

In the digital age of complex governance systems, citizens' demands are greater than ever on the provision of more citizen-centric and instant public services. This has helped to build momentum in Enterprise Architecture adoption and acceptance in the governments. A variety of architectures like The Open Group Architecture Framework (TOGAF), The Federal Enterprise Architecture Framework (FEAF), India Enterprise Architecture (IndEA) and Malaysia Government Enterprise Architecture (MyGovEA) [9, 10, 14] have contributed to the integrated and interoperable governance ecosystems. The models of business architecture, data architecture, application architecture and technology architecture are used as focal points in these frameworks to steer the architectures to integration in governance.

Other important values of EA are the transparency and accountability of governance, scalability and readiness to digital transformation [42, 43]. Different government agencies share information effectively, take decisions in a coherent way and provide public services in an integrated fashion using common governance frameworks and interoperable and citizen-friendly digital platforms provided by EA [6, 11]. The role of EA has gained greater and greater importance in recent years when facing new technologies such as Artificial Intelligence (AI), cloud computing, Geographic Information Systems (GIS) and tools of data-based governance in public administration, to facilitate the sustainable digital governance [4, 18].

While Enterprise Architecture (EA) has been proven to be very beneficial in the governance area, there are several issues involved in the use of EA in governance systems, particularly decentralized and rural governance systems, like governance maturity, institutional readiness, interoperability problems, technical capability and infrastructural disparity [19, 21].

3.2. Major Enterprise Architecture Frameworks in Governance

A number of international Enterprise Architecture (EA) frameworks have been created around the world to support the

integrated governance and interoperability, digital transformation and coordinated public administration. These models introduce the idea of a structured approach to linking the concept of the goals of governance, governance processes in the business and information systems and technological infrastructure in one digital governance ecosystem [6, 9].

The Open Group has presented the most popular architecture framework, The Open Group Architecture Framework (TOGAF) and provides a complete framework, The Architecture Development Method (ADM) lifecycle [9, 10] for the architecture development.

TOGAF provides a governance framework, how to standardize, and plan digital transformation in governance, and deals with the business architecture, data architecture, application architecture and technology architecture.

One of the first government-wide Enterprise Architecture initiatives of the United States Government is the Federal Enterprise Architecture Framework (FEAF). FEAF's goal is to improve interoperability, minimize multiple systems, enhance inter-agency coordination and boost public sector efficiency. The Business Reference Model (BRM), Data Reference Model (DRM), Service Reference Model (SRM) and Technical Reference Model (TRM) are a few models that are employed in FEAF [6, 41].

Later, a number of countries developed "national level" Enterprise Architecture frameworks to meet the requirements of governance. South Korea focuses on specific regulations on interoperability, and the concepts are being applied as the basic building blocks of South Korea's Government-wide Enterprise Architecture (KGEA) project, which provides a coordinated ICT governance mechanism [13, 15].

In the same way, in Malaysia Government Enterprise Architecture (MyGovEA) integration support framework provides business, data, application and technology reference models for the governance of Public-sector Administration.

Table 1. Comparative overview of major enterprise architecture frameworks in governance

Framework	Country/ Organization	Major Focus	Key Features	Governance Relevance
TOGAF	The Open Group	Enterprise transformation	ADM lifecycle, architecture governance, repositories	Strategic governance alignment
FEAF	United States	Federal governance integration	BRM, DRM, SRM, interoperability models	Whole-of-government architecture
IndEA	India	Integrated governance ecosystem	ONE Government vision, interoperability, scalability	Digital governance integration
MyGovEA	Malaysia	Public-sector architecture	Reference models for governance standardization	Public service coordination
Government-wide EA	South Korea	National digital governance	Interoperability, citizen-centric governance	Integrated service delivery

To ensure this vision of “ONE Government”, the Government of India has envisioned “digital governance systems” to be integrated, interoperable and citizen-centric. The India Enterprise Architecture (IndEA) framework has been developed [7, 16]. IndEA is working on the following elements of public governance: Integration, shared digital infrastructure, interoperability, scalability, openness and sustainability.

A second strand in the framework focuses on good governance principles and governance standardization, which will serve as an umbrella to mainstream and adapt to governance processes the inter-ministerial and inter-departmental cooperation, and to the decentralized governance institutions [7].

Overall, these typologies of EA frameworks show the importance of good, architecture-driven governance to better coordinate administration actions, increase governance interoperability, prepare for digital transformation and sustainable public service delivery. Table 1 provides a comparison of the key Enterprise Architecture frameworks and how they are relevant to governance. The concept of Principles and Governance Models holds the key and needs to be given a boost in the context of sustainable governance in Rural areas and e-Panchayat governance in India.

3.3. Digital Governance and e-government Evolution

With the advent of Information and Communication Technologies (ICTs), the nature of governance and administration of the public has undergone a drastic change. The initial e-Governance projects were largely in the areas of efficiency of service (information systems and internet platform) and of digitization of government services [56]. The electronic service delivery systems in the long run have turned into a more complex digital governance system, where interoperability, citizen participation, transparency and decisions based on data are promoted, and there is integration of public administration [1, 4].

In the context of e-Government and in the digital governance [42, 49], there is coordination between the Governments, collaboration between actors, real-time exchange of information, and citizens-oriented governance. The introduction of more sophisticated technologies, such as cloud, Artificial Intelligence (AI), big data analytics, Internet of Things (IoT), and Geographic Information Systems (GIS), is being viewed as a way to achieve better governance, public participation and sustainable development in the context of modern digital governance [4, 18].

Over the past few years, the integrated digital governance concepts of coordination, interoperability and efficiency have been gaining momentum in the various governments of the world. The initiatives in India, like Digital India, e-Panchayat, eGramSwaraj and GIS-based governance systems, are some

of the key steps towards decentralization and citizen centric governance system in India [23, 24, 36].

3.4. ICT Governance, Transparency, and Public Value

The implementation of ICT governance has turned out to be one of the most critical aspects of the modern digital governance system [42, 43]. Good governance of ICT leads to an efficient administration, institutional coordination, accountability and standardization of interoperability of digital public administration systems [47, 53]. In recent years, more focus has been placed on readiness to govern, stakeholders, policy and institutional capacity building and supporting digital technology implementation as a key element of a successful digital governance [47]. Public value has featured as an important research theme in the Digital Governance area, too. Public value [3] is the value of a digital governance system and public service at the level of the overall society, social, administrative and governance.

3.5. Sustainability and SDGs in Digital Governance

As the use of digital technologies has grown in governments to enable enduring and inclusive development, more efficient resource use, transparency and governance tenacity, sustainability has emerged as a key goal of digital governance systems [4, 5]. Efficiency in the public service delivery, citizen participation and participation, institutional accountability and facilitating evidence-based governance mechanisms have been identified as key enablers for digital governance in the context of Sustainable Development Goals (SDGs) [4, 17]. Governance mechanisms using ICT also help to enhance social inclusion, administrative efficiency and planning for sustainable development.

Various tools and frameworks to enable sustainability have been identified as Digital governance [4, 5], which enhances the governance coordination, transparency, interoperability and stakeholder engagement. With Artificial Intelligence (AI), the use of big data, cloud computing and Geographic Information Systems (GIS) have all played their parts in governance to enhance the implementation of policies, environmental monitoring and sustainable resource management [18]. The Indian Government's various initiatives like Digital India, e-Panchayat, Gram Manchitra and GeoMGNREGA clearly point in the direction of a continuous step towards encrusting a digital governance mechanism into the rural governance and decentralized governance in the context of sustainability issues [32, 33, 36]. Table 2 illustrates the different aspects of sustainability with respect to digital governance and e-Panchayat Systems.

3.6. Rural Governance and Decentralized Administration

One of the key elements of inclusive development, participatory democracy and local-level governance in developing countries like India is rural governance and decentralized administration. The governance system in the Panchayati Raj system (73rd Amendment Act)

Table 2. Sustainability dimensions in digital governance and e-Panchayat systems

Sustainability Dimension	Governance Objective	Digital Governance Components	Relevance to e-Panchayat Governance
Administrative Sustainability	Efficient and transparent governance	eGramSwaraj, AuditOnline, PFMS	Improved Panchayat administration
Economic Sustainability	Efficient resource utilization	Digital financial management systems	Transparent rural financial governance
Social Sustainability	Citizen participation and inclusion	GPDP platforms, citizen-centric governance	Inclusive rural governance
Environmental Sustainability	Sustainable resource management	GIS-enabled governance, GeoMGNREGA	Evidence-based rural planning
Institutional Sustainability	Governance continuity and coordination	Enterprise Architecture frameworks	Integrated decentralized governance
Technological Sustainability	Interoperable digital ecosystems	IndEA, cloud platforms, ICT governance	Long-term digital governance resilience

It is a three-tier governance system with gram panchayat, panchayat samiti and zila parishad that is responsible for administration and developmental planning in rural areas [22].

Decentralized governance has experienced a recent wave of digital governance tools that have been adopted to improve efficiency and effectiveness in administration, transparency and accountability, and delivery of public services [38, 50]. The initiatives such as e-Panchayat, eGramSwaraj, Panchayat Enterprise Suite (PES), Audit Online, Gram Manchitra and GeoMGNREGA are some of the bold programmes that facilitate bottom-up digital planning, budgeting, participative governance, spatial governance and monitoring.

4. Materials & Methods

The present study essentially adopts a qualitative and systematic literature review approach to examine the current global trends and practices of Enterprise Architecture in the governance and analyses their scope and implications in sustainable rural governance and e-Panchayat systems in India. The study primarily relies on conceptual synthesis and thematic analysis of existing literature in the categories of enterprise architecture, digital governance, ICT governance, interoperability, governance towards sustainability, decentralized governance and rural governance systems.

4.1. Review Methodology

The method adopted in this study is a qualitative systematic literature review method, which is in turn aimed to identify the international trends and practices of Enterprise Architecture (EA) in the context of governance and implications from the perspective of sustainable rural Governance and e-Panchayat system in the Indian context. The thematic synthesis and conceptual analysis of the literature on the theme of Enterprise Architecture, digital governance, interoperability, ICT governance, sustainability-oriented governance and decentralized rural governance systems [1, 3, 4, 6] is the main focus of the review. The second part of the methodology is an inter-country.

Comparative study of the governance models and the governance measures like e-Panchayat adopted in India to identify the key governance trends, challenges and implications for the governance strategy.

4.2. Literature Sources

Relevant literature was collected from academic databases, government documents, Policy documents, Conference papers and Institutional publications related to the topics of digital governance and EA. The dominant sources were articles from the journals included in Scopus, as well as documents such as the Government Framework document, Policy manual, e-Panchayat document and international governance studies based on TOGAF, FEAF, IndEA and Government-wide Enterprise Architecture [6, 7, 9, 10]. Additionally, the documents and operational reports of eGramSwaraj, Panchayat Enterprise Suite, Audit Online, Gram Manchitra, GeoMGNREGA and Digital India project were also analyzed to understand the structure and evolution of the rural digital governance system in India [17, 23, 24, 35, 36, 54-56].

4.3. Inclusion and Exclusion Criteria

The study is mainly focused on the literature around the following topics: Enterprise Architecture, digital governance, ICT Governance, Interoperability, Sustainability-oriented Governance, e-Governance and rural digital governance systems. The research and policy statements and governance in the context of digital transformation of the public sector and e-Panchayat system in India are also highlighted [6, 7, 17, 23-36, 54-56]. Not all literature was selected as it did not connect with the governance transformation and/or sustainability and decentralized administration/digital governance.

4.4. Thematic Classification Framework

The collected literature was systematically sorted into different themes that include: Enterprise Architecture frameworks, digital governance, ICT governance, Interoperability, Sustainability and SDGs, Citizen-centric governance, GIS-enabled governance and e-Panchayat

systems [23, 24, 30, 31, 54-56]. Thematic classification enabled structured analysis of the governance trends, challenges and opportunities for implementation, and helped to build sustainable rural digital governance ecosystems using the application of Enterprise Architecture.

4.5. Analytical Framework

Based on the synthesized literature, the study further introduces conceptual understanding on how the application of the principles of EA supports integrated, interoperable, transparent and sustainable to rural governance in India.

The Enterprise Architecture (EA) approach thus used a conceptual review of the literature, comparative governance analysis and thematic synthesis as the methodological approach in building up the analytical basis of the proposed Enterprise Architecture-driven framework for sustainable e-Panchayat governance.

5. Theoretical Analysis and Implications

5.1. Global Trends and Practices of Enterprise Architecture in Governance

Enterprise Architecture (EA) frameworks have been widely adopted in governance systems globally, with rapid progress in digital technologies [1, 6]. Governments are therefore more and more using EA to foster greater interoperability, coordination of governance, transparency, administrative effectiveness and citizen-centric public services in integrated digital governance environments [4, 7].

There are a number of countries with government-wide Enterprise Architecture (EA) frameworks that have initiated government modernization and digital transform. A few examples of architecture-led governance initiatives are Malaysia Government Enterprise Architecture (MyGovEA) [13, 14] and India Enterprise Architecture (IndEA) [6, 7] and in the United States (FEAF) and South Korea (KGEA), respectively. Countries, like Singapore and Bangladesh, have introduced Enterprise Architecture practices as enablers for public sector organizations' digital governance and coordination [8, 12].

More and more, in recent years, the term Enterprise Architecture is linked to sustainability-oriented governance, transparency, citizen participation and public value creation [3, 4]. In recent years, the introduction of different technologies such as Artificial Intelligence (AI), Cloud Computing, Big Data and Geographic Information Systems (GIS) has been used in the modern governance mechanism to achieve efficient governance and sustainable development [4, 18]. At the same time, digital governance platforms are enhancing accountability and financial transparency as well as participatory governance through integrated digital service delivery systems [2].

However, there are still several challenges that are affecting the Enterprise Architecture implementation, particularly in decentralized and rural Governance. Sustainable digital governance implementation is still facing big challenges such as governance fragmentation, interoperability, digital divide, infrastructure gaps and governance maturity gaps [19-21]. The initiatives such as IndEA, Digital India, and the e-Panchayat system are evidence of the growing importance of Enterprise Architecture to support the decentralized governance in the rural areas and integrated digital administration in India [7, 16, 23, 24, 30, 35, 36].

5.1.1. Evolution of Government-wide Enterprise Architecture

Government-wide Enterprise Architecture (EA) evolved as a strategic approach for improving governance integration, interoperability, administrative coordination, and digital transformation within public administration systems [6]. Early e-Government initiatives primarily focused on the digitization of individual government services; however, increasing governance complexity and fragmented information systems created the need for integrated architecture-driven governance frameworks [1, 41].

The Federal Enterprise Architecture Framework (FEAF) introduced by the United States Government represents one of the earliest and most influential government-wide EA initiatives aimed at improving inter-agency coordination, reducing system redundancy, and supporting collaborative governance through standardized reference models [6]. Subsequently, several countries adopted similar Enterprise Architecture approaches to strengthen digital governance and integrated public administration. South Korea implemented Government-wide Enterprise Architecture to enhance interoperability, centralized ICT governance, and citizen-centric service delivery [13, 14], while Singapore and Malaysia adopted architecture-driven governance models to support coordinated digital governance and public-sector modernization [8, 14].

In India, the India Enterprise Architecture (IndEA) framework was developed to support the vision of "ONE Government" by enabling interoperable, scalable, and citizen-centric governance systems through shared digital infrastructure and standardized governance principles [7, 16]. These developments demonstrate the global transition from isolated e-Government systems toward integrated and interoperable governance ecosystems supported by Enterprise Architecture frameworks.

5.1.2. Interoperability and Integrated Governance Systems

Today, interoperability is a key concept in digital governance and is helpful for interacting and communicating between digital platforms, government departments and administration units [1, 11]. Enterprise Architecture (EA) frameworks offer the possibility of providing public services

efficiently and coordinated administration, sharing of data and evidence-based decision making by having a common structure for governance and common digital infrastructure [6, 7].

The themes that are common in government-wide Enterprise Architecture initiatives, such as FEAF, IndEA and MyGovEA, are an emphasis on interoperability, common reference models, integrated data governance and coordinated application environments [6, 7, 14]. These are models that are more unified in their digital governance ecosystems and fewer fragmented in their systems; capable of enabling collaborative governance. Multiple platforms like eGramSwaraj, PFMS, AuditOnline, Gram Manchitra and GeoMGNREGA [23-27, 30-35] have been linked to the e-Panchayat system to open up new avenues to strengthen interoperability mechanisms in India. This integration will help to strengthen the transparency and coordination in governance and decentralized digital administration of Panchayati Raj Institutions.

However, despite all these developments, there are still interoperability challenges in governance systems, which are attributed to a number of factors, including the fragmentation of digital platforms, differences in data standards, coordination in governance and the infrastructural differences, particularly in rural governance systems [19, 38]. Therefore, it is important to have interoperable governance entities to support sustainable and integrated digital governance.

5.1.3. Citizen-Centric Digital Governance

The citizen-centric governance has been at the core of governance processes today, and it is about making things accessible, transparent, participatory and efficiently delivered to citizens. Citizen-centric digital governance is a citizen-centric governance where citizens' needs, expectations and participation are taken into primary consideration, rather than in the traditional government where administrators are the ones governing.

Digital governance platforms are now being used for delivering services online, participatory decision making, real-time engagement with the public to make governance more responsive and grievance redressal, etc. [2, 3].

To achieve citizen-centric governance, different countries have evolved an integrated digital governance system and have been moving towards an interoperable public services platform [8, 13]. Efforts for improving participative governance and strengthening citizens in decentralized rural

governance systems such as e-Panchayat, eGramSwaraj, Gram Panchayat Development Plans (GPDs) and Digital India are underway in India. Through these platforms, the digital planning, transparency of governance, public engagement and administration at the local level in Panchayati Raj Institutions is possible.

However, digital illiteracy, accessibility challenges, infrastructure, awareness and the digital divide (particularly in rural and marginalized communities) remain a problem in achieving effective citizen-centered governance [19, 20, 51]. Thus, inclusive and participatory digital governance is crucial to sustainable rural governance and working e-Panchayat systems.

5.1.4. ICT Governance, Transparency, and Accountability

Effective governance of ICTs, defined as the effective management of information technologies, governance processes, security standards and institutional coordination mechanisms [42, 43], is seen as an important factor that provides effective digital governance. Efficient administration, interoperability, standardization of governance and coordinated delivery of public services in integrated governance ecosystems are facilitated by good use of the ICTs [47, 53].

One of the most important advantages of governance through the use of ICTs for the public administration is the increase in transparency and accountability. Use of digital governance systems can provide a means for monitoring activities online, digital auditing, real-time financial management, transparent information sharing - and more - which can help eliminate administrative inefficiencies and reduce the risk of corruption [2]. In India, PFMS and Audit Online have created better financial transparency and accountability in the decentralized rural governance mechanism and Panchayati Raj Institutions (PRIs) [23, 31].

Moreover, in terms of public trust and effectiveness of governance, the effective use of ICT in governance can be used to achieve the values of citizen-centred service delivery, responsiveness of governance and transparency of institutions, which are components of public trust in and effectiveness of governance [3]. However, matters related to cybersecurity, governance maturity, infrastructural and institutional readiness are still challenging for governance systems [19, 21]. Thus, it is important to improve the governance of the ICT, so that there is a sustainable and transparent digital governance system.

Table 3. Major governance challenges in sustainable rural digital governance and e-Panchayat systems

Challenge Dimension	Major Issues	Governance Impact	Strategic Requirement
Interoperability	Fragmented governance platforms	Limited coordination and data sharing	Integrated Enterprise Architecture frameworks
Digital Infrastructure	Connectivity and ICT limitations	Restricted digital service accessibility	Improved rural digital infrastructure

Governance Maturity	Uneven institutional readiness	Inconsistent governance implementation	Capacity building and governance standardization
Digital Inclusion	Low digital literacy and accessibility barriers	Reduced citizen participation	Inclusive digital governance mechanisms
ICT Governance	Weak security and governance standards	Governance inefficiency and risks	Robust ICT governance frameworks
Sustainability Integration	Limited SDG-oriented governance models	Weak long-term governance resilience	Sustainability-oriented governance integration
Spatial Governance	Limited GIS integration	Weak evidence-based planning	Advanced GIS-enabled governance systems

5.1.5. Digital Inclusion and Governance Challenges

Although a lot has been achieved when it comes to digital governance, some problems remain that affect the building of sustainable and inclusive governance systems, particularly in decentralized administrative and rural regions [19, 20, 21]. The lack of digital infrastructure, low level of Internet connectivity, governance fragmentation, interoperability issues and institutional capacity are key issues. These barriers affect access to digital governance services and citizens' engagement with governance via digital services [20, 51]. Therefore, efforts are needed to make people more digital and 'digital governance ready' to develop sustainable citizen-centric digital governance ecosystems. The various aspects of governance issues associated with sustainable rural digital governance and e-Panchayat systems are summarized in Table 3 above.

5.1.6. Sustainability-Oriented Digital Governance

Apart from being one of the factors, nowadays digital governance is one of the dimensions of public administration which is based on using digital technology for inclusive development and for efficient resources management, transparency and long-term governance resilience [4, 5]. Digital governance systems are becoming an ever more effective enabler of the Sustainable Development Goals (SDGs), both by influencing the delivery of public services and the coordination of governance, participatory decision-making and evidence-based policy implementation [4, 17].

In Governance, new technologies are increasingly being adopted like GIS, cloud computing, Big data analysis and AI for sustainability and environmental monitoring, and to support streamlined governance. With the intentions of sustainable rural development and decentralized governance

transformation, there are some initiatives such as Digital India, e-Panchayat, Gram Manchitra, and GeoMGNREGA in India [17, 36], which show the increasing role of digital governance.

5.1.7. Global Best Practices and International Case Studies

Many countries have introduced Enterprise Architecture (EA) and digital governance approaches to support the integrated public administration, interoperability and citizen-centered approach to delivering services. The Federal Enterprise Architecture Framework (FEAF) was a program adopted in the USA to facilitate better inter-agency coordination and standardization of governance [6]. The Government-wide Enterprise Architecture (GEA) initiative on interoperability, centralized ICT governance and integrated delivery of public services was introduced in South Korea [13, 15] and architecture-driven governance in Singapore to ensure efficient and coordinated digital administration [8]. The focus for Malaysia was on establishing a framework of governance reference models for integrated public-sector transformation through the MyGovEA project [14] while Bangladesh launched National Enterprise Architecture projects to improve the coordination and interoperability of digital governance [12]. China has also seen the increasing importance of digital governance in facilitating sustainability and efficiency in governance in pilot city projects in recent years [18]. All of these international practices point to the significance of Enterprise Architecture, interoperability, standardization of governance and citizen-centric digital governance for the sustainable and integrated public administration systems. The lessons learnt from these governance models have been found useful to enhance the sustainable governance in rural areas and e-Panchayat systems in India. Table 4 offers a comparative overview of key governance practices in the various countries and enterprise architecture initiatives.

Table 4. Global governance practices and international enterprise architecture initiatives

Country/Region	Major Governance Initiative	Primary Governance Focus	Key Governance Features	Implications for India
United States	FEAF	Federal governance integration	Interoperability, reference models, and integrated administration	Whole-of-government coordination
South Korea	Government-wide EA	Digital governance transformation	Centralized ICT governance, citizen-centric services	Integrated governance ecosystems
Singapore	Smart Nation	Digital public	Data-driven governance,	Technology-enabled

	Governance	administration	smart governance systems	governance modernization
Malaysia	MyGovEA	Public-sector architecture	Standardized governance reference models	Governance standardization
Bangladesh	National Enterprise Architecture	Digital governance coordination	Interoperability and e-Government integration	Decentralized governance support
China	Digital Governance and Smart Governance Initiatives	Sustainability-oriented governance	AI-enabled governance, smart administration	Sustainable digital governance

5.2. Enterprise Architecture for Sustainable Rural Governance

In several developing countries, digital governance has been contributing significantly to the revolution of rural administration and decentralized governance mechanisms [4, 5]. In this context, in India, Enterprise Architecture (EA), ICT governance, interoperable digital platforms and citizen-centric governance systems have contributed to bolstering the process of digital transformation of Panchayati Raj Institutions and the rural governance system [5, 6, 23-35]. Enterprise Architecture is a critical tool to support the integration of governance, interoperability, transparency, administrative coordination and sustainable digital governance in decentralized administrative settings.

Under the Digital India initiative, the e-Panchayat ecosystem [17, 23-36, 54-56] is an important initiative towards integrated digital governance of rural areas using different platforms like eGramSwaraj, Panchayat Enterprise Suite (PES), AuditOnline, GeoMGNREGA and Gram Manchitra. Nevertheless, issues of lack of interoperability, digital divide, infrastructural gap, gap in governance maturity and non-uniform technological readiness level in the existing rural governance systems still exist [20, 38]. Hence, Enterprise Architecture-based governance frameworks for the development of sustainability, integration and citizen-centric rural digital governance ecosystem in India need to be improved.

5.2.1. Digital Transformation of Rural Governance

To a great extent, the process of digitization of rural governance processes in India has been underway for quite some time, and ICT plays a significant role in this process [17, 36]. The traditional form of rural administration is being

transformed into unified digital governance platforms, which seek to increase transparency, streamline administration, enhance citizen participation and provide decentralized services [25, 38]. The modernization of Panchayat Raj Institutions (PRIs) using e-governance technologies such as ICT-based governance systems is definitely a critical step towards digital India and the e-Panchayat Mission Mode Project (MMP).

Digital planning, online financial governance and governance oversight and transparency in rural governance systems are possible through digital governance platforms. However, the digital infrastructure, interoperability of governance, institutional preparedness and digital inclusion challenges have an impact on sustainable rural digital transformation [19-21].

5.2.2. e-Panchayat Ecosystem in India

The e-Panchayat ecosystem in India aims to boost the ability of Panchayati Raj Institutions (PRIs) by harnessing the potential of ICT in governance as an all-encompassing digital governance solution. Some of the platforms under the e-Panchayat Mission Mode Project (MMP) are: GeoMGNREGA, eGramSwaraj, Panchayat Enterprise Suite (PES), Audit Online, PFMS integration and decentralized administration. Table 5 provides an overview of the various elements and activities of e-Panchayat that are governed. These applications have improved transparency and coordination of governance, online auditing of governance, participatory planning and citizen-centred service delivery in rural governance systems [23, 29, 36]. As seen in Figure 3, an integrated landscape of different important digital governance platforms helps promote sustainable and interoperable e-Panchayat governance in India.

Table 5. Major components of the e-Panchayat governance ecosystem in india

Component/ Platform	Primary Function	Key Governance Features	Contribution to Rural Governance
eGramSwaraj	Planning and financial management	Digital planning, accounting, and monitoring	Integrated Panchayat administration
Panchayat Enterprise Suite (PES)	Governance application ecosystem	Interoperable governance applications	Digital governance integration
PFMS Integration	Real-time financial management	Online fund transfer and transparency	Financial accountability
Audit Online	Digital auditing system	Online audit management and	Governance transparency

		monitoring	
Gram Manchitra	GIS-enabled spatial planning	Asset mapping and infrastructure visualization	Sustainable rural planning
GeoMGNREGA	Geo-tagging and monitoring	Spatial governance and project tracking	Evidence-based governance
GPDP Platform	Participatory rural planning	Citizen participation and decentralized planning	Inclusive grassroots governance

5.2.3. GIS-Enabled Governance and Spatial Decision Support

In recent years, the application of GIS has become more common in the process of developing sustainable and evidence-based rural governance frameworks, the spatial planning process, resource mapping and decision making [32-35]. GIS helps in implementing governance platforms such as Gram Manchitra, GeoMGNREGA, etc., for geo-tagging,

monitoring infrastructure, and visualizing and analyzing assets in Panchayati Raj Institutions [32, 34, 35]. These systems facilitate the coordination of rural infrastructure and public resources, and provide better transparency and monitoring of rural governance and rural development planning.

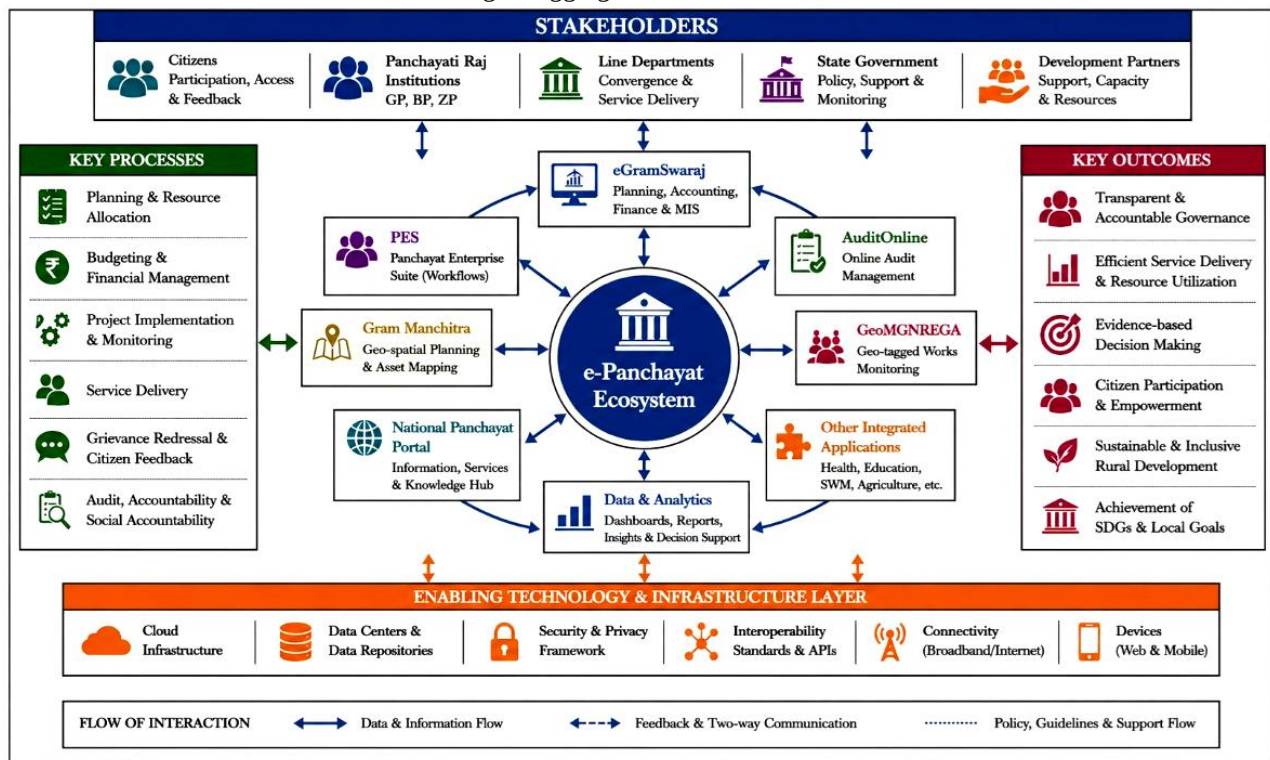


Fig. 3 Integrated e-Panchayat ecosystem for sustainable and interoperable rural digital governance in India

5.2.4. Participatory and Citizen-Centric Rural Governance

Participatory and citizen-centered governance is one of the major concerns for sustainable governance in rural areas because it makes the governance processes transparent, inclusive and engages citizens in governance processes [49, 50]. The use of digital governance platforms for citizens to participate in governance, online planning processes, grievance redress and governance monitoring, and even decentralized decision-making processes is now becoming increasingly common [2, 3]. Some initiatives in India have been working towards improving participatory governance and citizen engagement in Panchayati Raj Institutions, such as Gram Panchayat Development Plans (GPDPs), eGramSwaraj and Digital India [17, 25, 29].

They enable services to be provided in a citizen-centred way, governance to be transparent and local-level planning in a rural governance system. However, the issues linked to the effective involvement of citizens are Digital literacy, accessibility, awareness and digital divide, especially in rural and marginalized areas [20, 41].

5.2.5. Digital Inclusion Challenges in Rural Governance

One of the biggest challenges of sustainable rural governance is the digital divide in digital infrastructure, Internet accessibility, digital literacy and access to technologies between rural and urban areas [19, 21]. The rural and marginalized communities do not benefit greatly from digital governance services due to the lack of technical

awareness and infrastructure [20, 51]. These challenges restrict citizens' access to governance, their participation in governance and the implementation of digital governance systems of decentralized governance structures. Thus, digital inclusion and readiness for governance for sustainable and citizen-centric rural digital governance need to be developed.

5.2.6. Sustainability and SDG Alignment in Panchayat Governance

Sustainability and Sustainable Development Goals (SDGs) have entered into the governance and decentralized administration of rural areas [4, 17]. The digital governance platforms allow sustainable governance in Panchayat, through better planning, transparency, resource management and participatory decision-making mechanisms.

The use of evidence-based planning, monitoring of governance and efficient delivery of public services, through e-Panchayat, Gram Manchitra, GeoMGNREGA and Digital India, helps to promote sustainable development in the rural areas.

Digital governance and Enterprise Architecture provide an added layer of governance coordination, interoperability and administration in a sustainable fashion in Panchayati Raj Institutions [7, 16]. However, work needs to be done to keep moving towards becoming digitally inclusive, ready to govern and develop integrated governance frameworks that support the long-term development and sustainability goals.

6. Proposed Enterprise Architecture Framework for Sustainable e-Panchayat Governance

Despite the introduction of several initiatives, such as eGramSwaraj, Panchayat Enterprise Suite, Audit Online, Gram Manchitra and GeoMGNREGA to facilitate digital governance in rural areas in India [23-35], there are some challenges of interoperability, governance fragmentation and digital inclusion [19, 20]. A reference Enterprise Architecture model for sustainable and interoperable e-Panchayat governance is illustrated in Figure 4. Accordingly, this section gives an insight into the Enterprise Architecture (EA) driven framework for sustainable, transparent, interoperable and citizen-centric e-Panchayat governance for India.

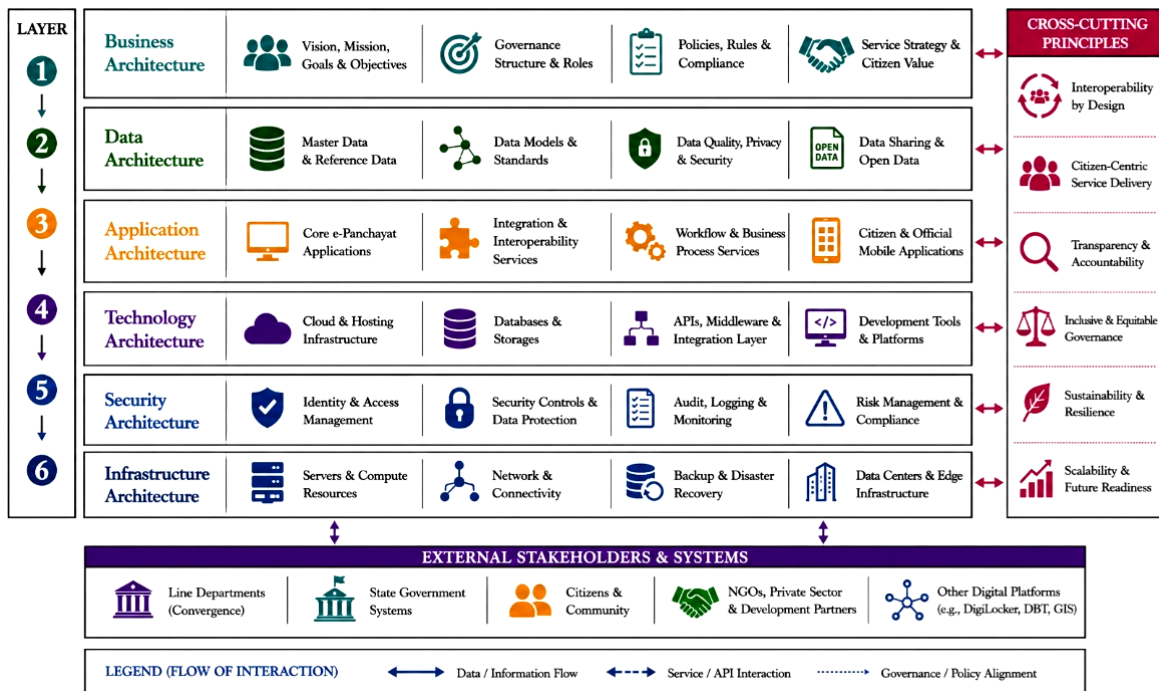


Fig. 4 Reference enterprise architecture for sustainable and interoperable e-Panchayat governance in India

6.1. Need for an Integrated EA-driven Governance Framework

Increased need for a governance system that is integrated and interoperable in rural areas, as the governance system is becoming complex [16]. Grassroots of rural India have seen various successful digital governance services in digital governance, digital administration and digital monitoring of governance processes, but these systems are often part of disjointed and interoperable governance systems with varying

levels of governance maturity, digital readiness and institutional coordination [19, 38].

It is necessary to integrate governance mechanisms and use them to share data, provide citizens-centred services, plan for space, promote transparency in the governance process and evidence-based decision making [4, 5]. It is possible to achieve such integration through strategic models and governance of Enterprise Architecture, common governance

models, common digital platforms, common data spaces and common ICT governance processes. Furthermore, the integration of sustainability aspects and the use of GIS as a governance-enabling tool into Enterprise Architecture can enable participative governance and digital participation in governance systems to give a significant boost to decentralized rural governance systems.

Hence, it is essential to have a strong Enterprise Architecture (EA) based governance framework system that could support a sustainable, transparent, interoperable and citizen-centric e-Panchayat governance system in India.

6.2. Proposed Conceptual Framework

The proposed conceptual framework is based on the integration of Enterprise Architecture for a unified e-Panchayat governance ecosystem to achieve through the integration of Enterprise Architecture (EA), digital governance, ICT governance, interoperability, sustainability and citizen-centric rural administration [4, 7]. It has been centered around coordinated governance, interoperable digital platforms, shared data environments, GIS-based decision support systems, transparent governance mechanisms and participatory governance processes. Figure 5 represents the proposed Enterprise Architecture-driven framework for sustainable and integrated e-Panchayat governance.

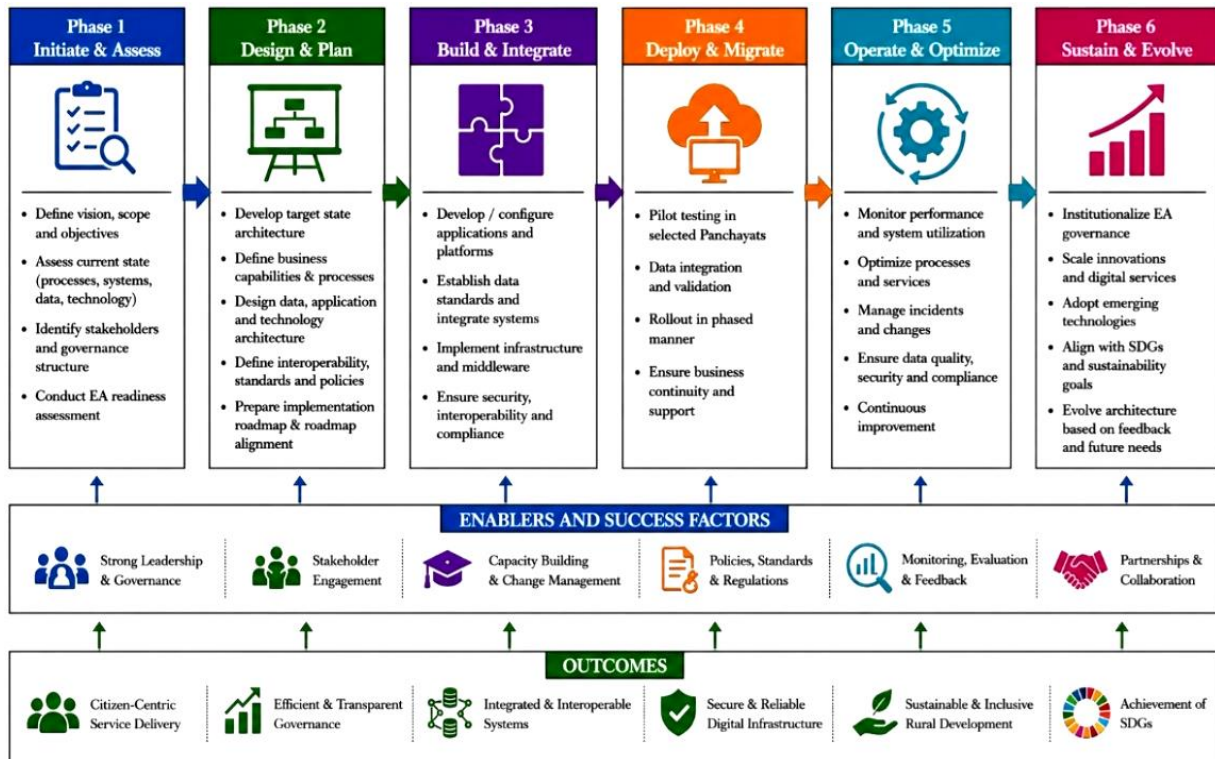


Fig. 5 Proposed enterprise architecture-driven framework for sustainable and integrated e-Panchayat governance in India

6.3. Proposed Interoperability Architecture

The proposed interoperability architecture focuses on the idea of an integrated coordination of various major platforms of e-Panchayat via common data environments and interoperable governance processes [23-35]. The architecture supports and promotes seamless information sharing, coordinated governance processes, spatial decision support, as well as transparency of finances and service delivery to citizens in a decentralized rural governance system.

Besides this, there are some new aspects that are introduced in this proposed architecture, such as Enterprise Architecture principles and the governance mechanisms enabled by GIS, sustainability-oriented governance mechanisms and lastly, the ICT governance makes the e-

Panchayat administration transparent, interoperable and efficient [4, 6, 7]. Figure 6 shows the proposed interoperability and impact framework for Enterprise Architecture-driven sustainable e-Panchayat governance.

The proposed framework is not only different from the current EA and digital governance framework, but it also brings together EA, interoperability, ICT governance, GIS-based decision support, citizen involvement, digital inclusion and sustainability in a single framework, dedicated to the decentralized rural governance and e-Panchayat context. The proposed framework provides a comprehensive framework for government-wide architecture, interoperability and digital governance, while the existing frameworks mentioned above provide important foundations for that. Thus, its role is to offer

a more holistic and contextual perspective, not necessarily an experimental edge. The present study does not attempt a quantitative performance comparison with other available frameworks, as it is a qualitative literature synthesis and conceptual analysis study and can be conducted in future empirical studies.

6.4. Policy and Administrative Recommendations

Strengthening Enterprise Architecture governance and interoperability standards, as well as the ICT governance and integrated e-infrastructure at decentralized administrative systems, is required to have good execution of sustainable e-Panchayat governance [6, 7].

Integrated governance platforms, data governance standard mechanisms, cybersecurity and interoperable digital ecosystems for better governance coordination and transparency should be included in policies.

In addition, policies must not be overlooked that aim towards increasing digital inclusion [19, 20], and similarly, technical capacity building, governance and citizen participation in rural governance systems must be tackled. GIS can also be utilized to strengthen governance and participatory planning mechanisms, and sustainability orient governance policies to strengthen further efficient and citizen-centric governance and administration in rural India [27-30, 59].

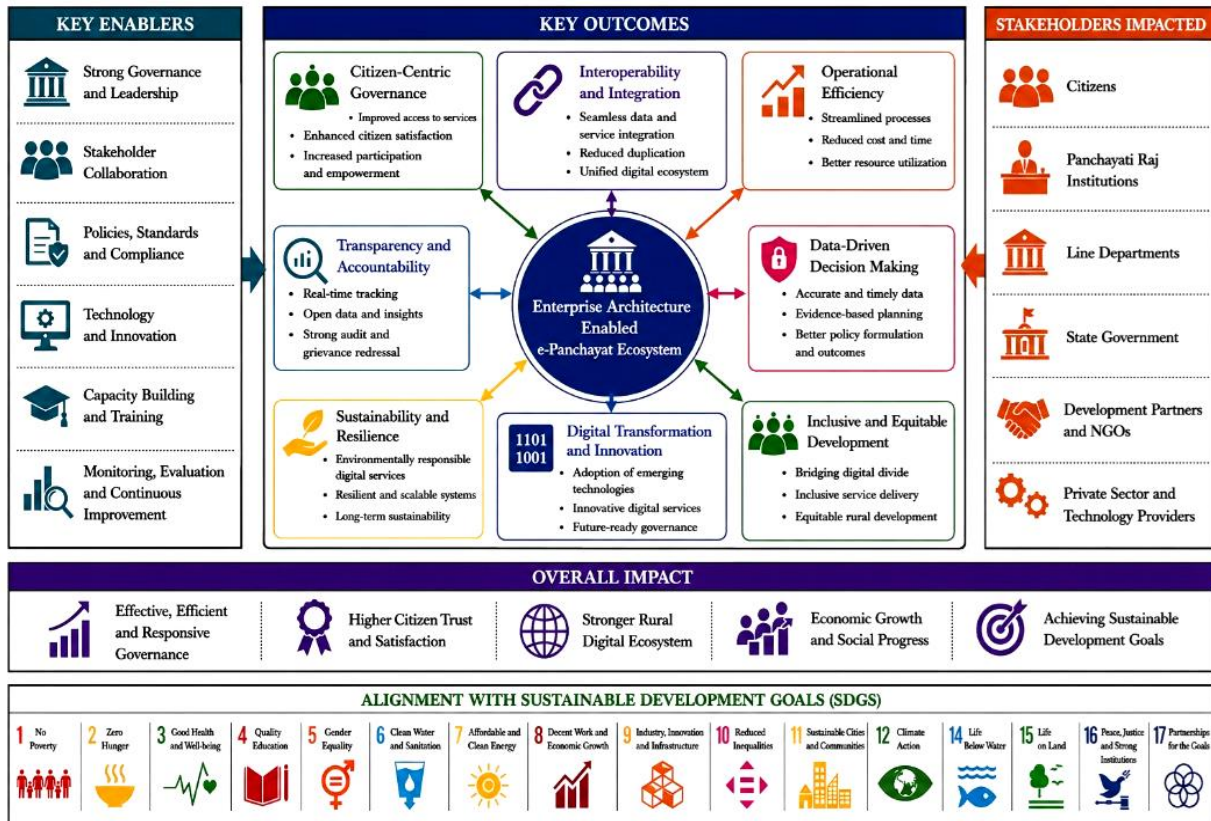


Fig. 6 Proposed interoperability and impact framework for enterprise architecture-enabled sustainable e-Panchayat governance

6.5. Roadmap for Sustainable Digital Panchayat Governance

In a decentralized governance system, sustainable digital Panchayat governance will need to be strengthened in a phased manner and will be facilitated by implementing Enterprise Architecture, governance interoperability, digital infrastructure, GIS-enabled planning and citizen participation [6, 7]. Digital inclusion and capacity building of governance and an integrated governance mechanism will also help in creating citizen-centric and transparent governance in rural India [19, 20]. The proposed strategic blueprint with respect to strengthening sustainable, interoperable and citizen-centric digital panchayat governance is shown in Table 6.

7. Research Gaps and Future Directions

Although there are numerous literatures available in the field of enterprise architecture (EA), there is very little literature available in the field of an integrated EA-driven framework of sustainable governance for rural areas and e-Panchayat systems [4, 6]. Concerning the integration in a 'decentralized rural digital governance ecosystem' [32-35, 3], there is still limited research on challenges related to sustainability-oriented governance, GIS-enabled governance and digital inclusion and participatory governance. Adopting sustainable rural digital governance in India is plagued with multiple issues, including interoperability, governance

fragmentation, governance maturity, digital divide and institutional readiness [19, 38]. Moreover, there is limited research on understanding how the integrated governance structures can be used to facilitate convergence of all the platforms, such as eGramSwaraj, Panchayat Enterprise Suite

(PES), PFMS, Audit Online, Gram Manchitra and GeoMGNREGA and create a governance ecosystem. Table 7 provides a summary of major issues that remain to be addressed and the way forward for the sustainable digital governance and e-Panchayat system.

Table 6. Strategic roadmap for sustainable digital panchayat governance

Strategic Area	Key Actions	Expected Governance Outcome	Implementation Priority
Enterprise Architecture Adoption	Develop integrated governance architecture frameworks	Improved interoperability and governance coordination	High
Digital Infrastructure	Strengthen rural ICT and connectivity systems	Enhanced digital accessibility and service delivery	High
ICT Governance	Establish governance standards and cybersecurity frameworks	Secure and transparent governance systems	High
GIS-enabled Governance	Expand spatial governance and geospatial planning systems	Evidence-based rural development planning	Medium
Digital Inclusion	Improve digital literacy and citizen accessibility	Inclusive citizen-centric governance	High
Capacity Building	Provide technical and governance training	Improved governance readiness and sustainability	Medium
Participatory Governance	Strengthen GPDP and citizen engagement mechanisms	Enhanced public participation and accountability	Medium
Sustainability Integration	Align governance systems with SDGs and sustainability goals	Long-term sustainable rural governance	High

Table 7. Research gaps and future directions in sustainable digital governance and e-panchayat systems

Research Domain	Identified Research Gap	Future Research Direction
Enterprise Architecture	Limited application of EA in decentralized rural governance	Development of integrated rural governance architecture frameworks
Interoperability	Insufficient integration among governance platforms	Advanced interoperable governance ecosystems
Sustainability Governance	Limited SDG-oriented governance models	Sustainability-driven digital governance frameworks
Digital Inclusion	Persistent digital divide in rural governance	Inclusive citizen-centric digital governance strategies
GIS-enabled Governance	Limited integration of spatial analytics in governance	AI- and GIS-driven decision-support systems
ICT Governance	Weak governance maturity and cybersecurity mechanisms	Governance maturity assessment and secure ICT frameworks
Citizen Participation	Limited participatory governance integration	Advanced digital participatory governance models
Emerging Technologies	Limited application of AI and blockchain in Panchayat governance	Smart village governance and intelligent governance ecosystems

Future research may focus on AI governance systems, smart village governance, blockchain-based governance transparency, governance maturity assessment systems and advanced GIS-based rural governance systems.

The implementation of the e-Panchayat sustainable governance system, with the assistance of Enterprise Architecture and performance evaluation model in the Indian context, can also be further researched.

8. Conclusion

The importance of Enterprise Architecture (EA) in the integrated, interoperable and citizen-centric digital governance ecosystem has increased considerably given the rapid advancements of digital technologies, and the complexity of the governance systems [6, 7]. This study analyzed the global trends and practices around the domain of Enterprise Architecture (EA) in the context of governance and also discussed the implications of the trends in the context of sustainable rural governance and e-Panchayat in India. The

study indicated the increasing importance of Enterprise Architecture for the governance coordination, interoperability, and transparency, as well as for public administration with a focus on ICT governance and sustainability. The study also demonstrated the value of Enterprise Architecture (EA) frameworks as part of an integrated digital governance system because it has great potential to impact decentralized governance and rural digital transformation.

A summary of the key findings of the study is listed below:

- Government-wide Enterprise Architecture frameworks such as FEAF, KGEA, IndEA, and MyGovEA have played an important role in strengthening governance interoperability, administrative coordination, and digital governance transformation [9, 14].
- Digital governance systems are increasingly evolving towards a citizen-centric and sustainability-oriented governance system, and interoperable digital platforms and ICT governance mechanisms are getting engaged [3-5].
- e-Panchayat, eGramSwaraj, Panchayat Enterprise Suite (PES), Audit Online, GeoMGNREGA and Gram Manchitra are the fruits of a new ecosystem in India that has completely transformed the way decentralized digital governance, transparency, participatory planning and governance monitoring are done in Panchayati Raj Institutions [24, 26, 28, 31, 36]. Sustainable rural governance in terms of better planning, monitoring and evidence-based governance is important, and GIS-based governance and spatial decision support systems are significant [33, 35].
- The governance fragmentation, interoperability, digital divide, difference in governance maturity and

infrastructural issues are the major challenges that need to be addressed for sustainable implementation of the rural digital governance in India [20, 38].

- Citizen participation and transparent administration, Sustainable alignment, Governance interoperability, Common digital infrastructure and integrated governance focus on strengthening the sustainable e-panchayat governance systems and are the key elements of the proposed Enterprise Architecture-driven framework.
- Lastly, the study highlights that Enterprise Architecture-driven governance frameworks can play a critical role in supporting sustainable, transparent, interoperable, and citizen-centric rural digital governance ecosystems in India. Therefore, these topics - strengthening integrated governance mechanisms, digital Inclusion, ICT governance and sustainable-oriented administration in Panchayati Raj Institutions will continue to be of utmost importance for efficient and resilient Panchayat governance in the future digital space.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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