Scientific Research Publishing

Open Journal of Social Sciences, 2026, 14(8), 582-593
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Measuring the Maturity of Archives Management in the Digital Era: Model Construction and Path Design

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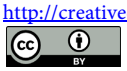
How to cite this paper: Yang, Y., & Liang, L. (2026). Measuring the Maturity of Archives Management in the Digital Era: Model Construction and Path Design. *Open Journal of Social Sciences, 14,* 582-593.
https://doi.org/10.4236/jss.2026.148034

Received: July 24, 2026
Accepted: August 22, 2026
Published: August 25, 2026



Abstract

Digital transformation has increased electronic records, long-term preservation demands, and evidence-based governance needs. This conceptual study develops a maturity assessment framework for digital archives management, primarily for public archives, institutional archive rooms, and university archives. Drawing on CMMI, information governance and e-government maturity models, and digital preservation practices, it compares international and Chinese approaches and constructs a five-level model covering six capability domains: strategic governance, institutional standards, human resources and organizational capability, technical infrastructure, business processes and data management, and security and risk management. It also specifies domain-level evidence, a conservative lowest-domain rule for overall classification, and staged improvement paths. The framework moves assessment beyond static compliance checking toward continuous capability development while remaining subject to expert review, pilot application, and empirical validation.

Keywords

Digital Archives Management, Capability Maturity Model, Maturity Assessment Framework, Capability Enhancement Path, Digital Preservation

1. Introduction

The rapid development of information technologies and the exponential growth of electronic records have pushed archival management into a comprehensive digital transition. Traditional paper-centered workflows are increasingly unable to meet the requirements of digital governance, evidence retention, long-term preservation, and public information services.

Yet institutional capability for digital archival management varies substantially. Some institutions remain at the level of basic scanning, fragmented storage, and isolated information systems, whereas others have established integrated and standardized digital archival governance systems. How to evaluate an institution's maturity and identify targeted improvement priorities has therefore become an important issue in archival science.

Maturity models provide a useful analytical lens for addressing this problem. The Capability Maturity Model and its integrated form, CMMI, classify organizational process capability into progressive stages and link evaluation results with structured improvement actions (Chrissis, Konrad, & Shrum, 2011). Compared with static checklist-based audits, maturity models emphasize process evolution, continuous optimization, and staged capability enhancement.

In the international context, assessment tools for digital preservation have become relatively mature. The Digital Preservation Coalition Rapid Assessment Model (DPC RAM) provides a tiered self-assessment tool for organizational digital preservation capability (Digital Preservation Coalition, 2021). The NDSA Levels of Digital Preservation establish progressive requirements for storage, integrity, metadata, file formats, and security (Phillips, Bailey, Goethals, & Owens, 2013). These frameworks offer valuable references for digital archival preservation, although their primary focus remains technical preservation capacity rather than the full scope of archives management.

In China, digital archives maturity assessment is still developing but has accumulated a foundation in standards and practice. In the broader field of data governance, the national standard GB/T 42129-2022 Data Management Capability Maturity Assessment Model (DCMM) identifies major capability domains for organizational data management and defines five maturity levels (National Information Technology Standardization Technical Committee, 2022). As archival institutions promote digital archives management, they likewise need coordinated development across strategy, standards, technology, data quality, and security. Related data management frameworks also emphasize strategy, governance, standards, quality, security, and lifecycle management as core capability areas (DAMA International, 2017).

Within the archival domain, the National Archives Administration has issued evaluation measures for digital archive room construction and assessment standards for digital archives, which set clear requirements for institutional archive rooms and comprehensive archives (Office of the National Archives Administration, 2016). However, such measures emphasize compliance certification rather than progressive improvement. The Hangzhou Municipal Archives Bureau also explored a maturity model for the "four properties" of electronic records—authenticity, integrity, usability, and security—demonstrating the feasibility of applying maturity models to archival management (Research Group of Hangzhou Municipal Archives Bureau, 2016).

Academically, studies have examined digital preservation capability maturity,

single-track electronic records management, archival data security governance, and archival data governance maturity in the big data era (Xiao & Chen, 2016; Zhou & Han, 2020; Jin & Yang, 2022). These studies provide important theoretical and practical support, but an integrated maturity framework covering the overall capability structure of digital-era archives management remains insufficiently developed.

Accordingly, this study synthesizes relevant maturity-model theories, standards, and practical cases to construct a systematic maturity model for digital archives management and to propose corresponding implementation paths. The objective is to support archival institutions in diagnosing their current capability level and advancing from elementary digitalization toward standardized, quantified, and continuously optimizing management.

2. Research Design and Theoretical Foundations

2.1. Scope, Unit of Assessment, and Research Methodology

The intended unit of assessment is an archival institution or an organizational archival function with identifiable governance responsibility, personnel, systems, workflows, and security controls. The framework is designed primarily for public archives, institutional archive rooms, and university archives. It may inform libraries, museums, and other memory institutions, but it should not be assumed to apply equally to them without adapting the domain definitions, evidence requirements, and service indicators to their mandates.

The study adopts a conceptual model-development approach combining literature review, comparative analysis, and purposive case analysis. Literature, standards, and practice reports were examined to identify recurring maturity levels, capability domains, and observable evidence. Following the design-science view that maturity models should make their scope, construction logic, and application rules explicit (Mettler, 2011), the analysis records how each source contributes to the proposed domains and level descriptions.

DPC RAM and the Hangzhou case were selected as analytically contrasting cases rather than as a statistically representative sample. DPC RAM was selected because it is publicly documented, uses tiered self-assessment, and evaluates organizational and service capabilities for digital preservation. The Hangzhou case was selected because it is situated in the Chinese archival context and applies maturity logic to authenticity, integrity, usability, and security. Their relevance, scope, evidence base, and transferability to archival management were used as the explicit comparison criteria. Because this study is a purposive conceptual synthesis rather than a systematic review, the cases are not used to estimate prevalence or support statistical generalization.

The remaining analytical steps compare the selected practices across assessment purpose, scope, level structure, evidence requirements, and improvement use; synthesize model components; define the five levels and six domains; specify assessment evidence; and design staged improvement paths.

2.2. Capability Maturity Model Integration (CMMI)

CMMI represents the origin and archetype of contemporary maturity models. It was designed to assess and improve organizational process capability by defining staged maturity levels and key process areas. In general, CMMI divides organizational capability into five levels: Initial, Managed, Defined, Quantitatively Managed, and Optimizing. The logic of gradual progression, from ad hoc practices to standardized, measured, and continuously improved processes, is directly relevant to digital archives management (Chrissis et al., 2011).

2.3. Information Governance Maturity Model

The information governance maturity model developed by ARMA International is structured around principles such as accountability, transparency, integrity, protection, compliance, availability, retention, and disposition (ARMA International, 2017). It evaluates the maturity of governance practices across each principle and identifies weak links for targeted improvement. For archival institutions, this model is particularly relevant because archival work requires balanced development in authenticity, integrity, availability, security, compliance, and controlled disposition.

2.4. E-Government Maturity Model

E-government maturity models commonly describe a progression from information publication to interaction, transaction processing, integration, and intelligent services. Layne and Lee's (2001) four-stage model, for example, moves from cataloguing and transactions to vertical and horizontal integration. Such models reveal the progressive deepening of digital public services and provide a reference for archival services, which increasingly interact with government service platforms and cross-departmental data systems. Later work also treats digital government maturity as a technology-driven model linked to platform integration and service transformation (Layne & Lee, 2001; Jussupova, Bokayev, & Zhussip, 2019).

3. Comparative Analysis of Digital Archives Management Maturity Assessment Practices

3.1. International Practices

Internationally, the application of maturity models in archival management has mainly concentrated on digital preservation capability assessment. DPC RAM provides a rapid self-assessment framework covering organizational and service capabilities for digital preservation (Digital Preservation Coalition, 2021). It uses consistent levels that allow organizations to identify capability gaps and set improvement priorities. The NDSA Levels of Digital Preservation, although not a maturity model in the strict sense, similarly presents staged requirements for storage redundancy, integrity checking, metadata, file formats, and security (Phillips et al., 2013).

These international practices are concise and operational, making them useful for libraries, archives, museums, and other memory institutions with different resource levels. Nevertheless, they tend to emphasize the technical management of digital objects, while organizational governance, workforce development, business process redesign, and data lifecycle management are not always fully integrated into the same assessment framework.

3.2. Practices in the Chinese Context

In China, maturity assessment for digital archives management is still at an exploratory stage, but administrative standards and academic research have provided a foundation. The Measures for the Evaluation of Digital Archive Room Construction use a scoring mechanism that covers organizational leadership, system development, infrastructure, business application, and security assurance (Office of the National Archives Administration, 2016). This approach is useful for certification, but it is less focused on continuous capability progression.

More maturity-oriented explorations have also appeared. The Hangzhou Municipal Archives Bureau developed a maturity model and assessment guidelines for assuring the "four properties" of electronic records. This case shows that maturity assessment can be adapted to archival requirements and can help institutions locate specific gaps in authenticity, integrity, usability, and security (Research Group of Hangzhou Municipal Archives Bureau, 2016).

Academic studies in China have further expanded the application of maturity thinking. Research has addressed digital preservation capability, electronic records management, archival data security governance, and big-data-oriented archival governance (Xiao & Chen, 2016; Zhou & Han, 2020; Jin & Yang, 2022). These studies are closely connected with archival business scenarios, but a comprehensive model that integrates strategy, standards, people, technology, process, data, and security is still needed.

Across the two cases, the comparison focuses on assessment purpose, unit and scope, level structure, evidence requirements, and improvement use. DPC RAM contributes a concise domain-based self-assessment logic, whereas the Hangzhou case demonstrates the adaptation of maturity levels to archival requirements for electronic-record authenticity, integrity, usability, and security. The proposed framework extends these elements by integrating governance, standards, personnel, technology, process and data, and security within a single institutional profile; it does not treat either case as a complete or directly transferable model.

4. Construction of the Digital Archives Management Maturity Model

Building on the above theoretical and practical analysis, this study constructs a digital archives management maturity model for assessing institutional capability in the digital environment. The model contains five maturity levels and six capability domains, and it is designed to support both self-assessment and staged im-

provement.

4.1. Model Design Principles

Archival business orientation. The model is structured around the full lifecycle of archival work, including records collection and accession, arrangement and description, preservation and custody, access and services, appraisal, statistics, and evaluation.

Digital technology integration. The model emphasizes new digital requirements, including electronic records management, long-term digital preservation, archival information systems, cybersecurity, data security, and emerging intelligent technologies.

Hierarchical progression. Each maturity level represents a qualitative stage of development, drawing on general maturity-model logic while being adapted to archival management realities.

Measurability and auditability. Indicators should be objectively verifiable wherever possible, using quantifiable or inspectable evidence rather than purely subjective judgment.

Improvement orientation. Each level and indicator should not only describe the current status but also point to the next-step improvement actions needed for capability enhancement.

4.2. Maturity Level Classification

Following the logic of CMMI and DCMM, the model divides digital archives management maturity into five levels: Initial, Managed, Defined, Quantitatively Managed, and Optimizing (Chrissis et al., 2011; National Information Technology Standardization Technical Committee, 2022) (**Table 1**).

Level 1: Initial. Digital archives management is ad hoc, reactive, and weakly standardized. The institution lacks clear objectives, policies, and unified systems, and digital activities rely largely on temporary measures.

Level 2: Managed. The institution begins to recognize the importance of digital archives management. Basic policies, pilot systems, and initial staff capacity are established, but implementation remains partial and uneven.

Level 3: Defined. Digital archives are treated as strategic information resources. Standardized policies, processes, data rules, and information systems cover the main archival business activities at the organizational level.

Level 4: Quantitatively Managed. Standardized management is supplemented by metrics, monitoring, feedback, and continuous improvement. Data-driven decision-making supports performance control, quality improvement, and risk monitoring.

Level 5: Optimizing. Digital archives management reaches a continuously improving and evidence-based stage. Archival systems are deeply integrated with organizational digital strategy; performance evidence guides experimentation and learning; and advanced technologies may be adopted where they demonstrate archival value and controlled risk.

Table 1. Classification of digital archives management maturity levels.

Maturity Level	Core Characteristic	Key Manifestations
Level 1: Initial	Disordered and reactive	Reliance on traditional experience; no unified standards; fragmented system deployment; temporary problem solving
Level 2: Managed	Partially standardized	Basic policies in place; pilot systems established; minimum compliance met; partial electronic management
Level 3: Defined	Comprehensively standardized	Full-process standardization; systems cover core business; data governance framework initially formed
Level 4: Quantitatively Managed	Quantitative assessment and refined control	Performance measurement; data-driven decision-making; monitoring of efficiency, quality, and security risks
Level 5: Optimizing	Continuous optimization and demonstrated innovation	Deep strategic integration; sustained improvement; demonstrated archival value; validated advanced practices; sectoral contribution

4.3. Capability Domains and Evaluation Indicators

The model establishes six capability domains to cover the key elements of digital-era archives management.

Strategic Governance Domain. This domain assesses top-level design for digital archives management, including strategic alignment, leadership structure, planning mechanisms, and integration into organizational performance evaluation.

Institutional Standards Domain. This domain assesses the development of policies, standards, procedures, metadata rules, accession requirements, and implementation mechanisms for digital archives management.

Human Resources and Organizational Capability Domain. This domain assesses staffing, digital skills, training systems, cross-departmental collaboration, professional development, and innovation culture.

Technical Infrastructure Domain. This domain assesses archival management systems, storage and backup reliability, integration with business systems, network infrastructure, and the adoption of emerging technologies.

Business Processes and Data Management Domain. This domain assesses the digitization of archival workflows and data lifecycle management, including electronic accession, digital arrangement, metadata quality, data use, and process optimization.

Security and Risk Management Domain. This domain assesses cybersecurity, access control, integrity verification, disaster recovery, audit trails, privacy protection, and risk-response mechanisms.

4.4. Assessment Rules, Observable Evidence, and Validation

Assessment is conducted at the capability-domain level before an overall institu-

tional result is assigned. For each domain, assessors identify the highest level for which all mandatory baseline requirements are supported by documentary or system evidence. The institution's overall maturity level is conservatively defined by the lowest of the six domain levels (the "short-board" rule), because a critical weakness in any domain may constrain institution-wide reliability. The complete six-domain profile must also be reported to preserve diagnostic detail. An arithmetic average may be presented as supplementary information, but it should not override a domain that fails to meet the mandatory baseline. Any alternative weighting or aggregation rule should be stated and justified in advance.

Table 2 provides examples of observable evidence and advanced practices. These examples are illustrative rather than exhaustive and should be adapted to institutional mandates, scale, legal obligations, and resource conditions.

Table 2. Observable evidence and advanced practices by capability domain.

Capability Domain	Mandatory Baseline Evidence	Advanced Evidence or Practices
Strategic Governance	Approved strategy or annual plan; named accountable unit; budget and resource records; performance-review records	Cross-organizational governance board; quantified portfolio oversight; external benchmarking
Institutional Standards	Approved policies and procedures; metadata and format rules; version-controlled documents; implementation and audit records	Formal revision cycle; machine-actionable rules; participation in standards development
Human Resources and Organizational Capability	Job descriptions; staffing records; training plans and attendance; competency assessments	Interdisciplinary teams; certification pathways; succession planning; innovation incentives
Technical Infrastructure	System inventory; architecture and interface documents; backup logs; recovery-test records; maintenance records	Interoperable platforms; automated monitoring; preservation planning; verified technology refresh
Business Processes and Data Management	Documented workflows; transfer and accession records; metadata-completeness reports; quality-control and access logs	End-to-end automation; lifecycle analytics; reusable data services; continuous process optimization
Security and Risk Management	Access-control matrix; integrity checks; incident logs; risk register; continuity and disaster-recovery drills	Continuous risk monitoring; independent audit or certification; tested response scenarios; privacy and algorithmic oversight

Mandatory baseline requirements define the minimum conditions for a level and cannot be compensated for by isolated advanced practices. For example, an institution cannot be classified at the Defined level without organization-wide policies and coverage of core archival processes, even if it has deployed an advanced technical tool. Conversely, intelligent technologies are possible advanced

practices at the Optimizing level rather than universal mandatory requirements. Classification at that level depends on sustained improvement, demonstrable archival value, documented controls, and organization-wide integration.

Tools such as artificial intelligence, blockchain, and knowledge graphs should therefore be assessed by their contribution to authenticity, integrity, accessibility, efficiency, or knowledge services, together with documented risks, human oversight, security controls, and preservation sustainability—not by deployment alone. Digital preservation research likewise emphasizes explicit planning, evidence, trust, and risk management rather than technological novelty as an end in itself (Becker et al., 2009; Duranti & Rogers, 2012; Yakel et al., 2013; Frank, 2022).

The present model is a preliminary conceptual framework, not a validated certification instrument. Before formal or comparative use, the domain definitions and indicators should be reviewed by archival and digital-preservation experts, piloted in different institution types, and tested for inter-rater consistency, reliability, and construct validity. Feedback from application should then be used to revise weights, thresholds, evidence rules, and level descriptions, consistent with iterative maturity-model development (Mettler, 2011). The resulting six-domain, five-level maturity assessment framework is summarized in **Figure 1**.

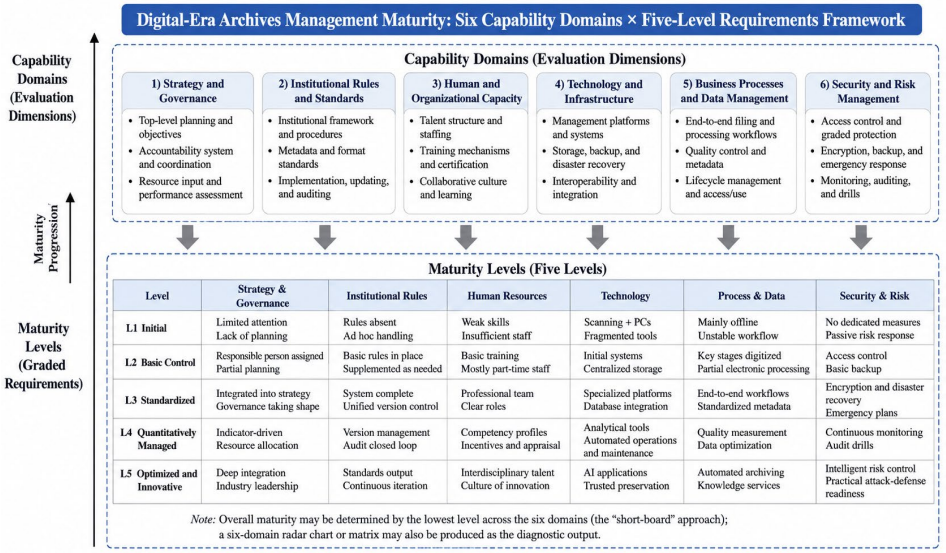


Figure 1. Digital Archives Management Maturity Model: Six Capability Domains × Five-Level Framework. Note: The Level 5 technology examples in the figure are illustrative advanced practices. They do not independently determine maturity; classification requires demonstrated archival value, organization-wide integration, and documented risk controls.

5. Path Design for Digital Archives Management Maturity Enhancement

Guided by the maturity model, archival institutions should develop phased improvement roadmaps based on their current capability level. Because institutions start from different baselines, path design should be hierarchical, targeted, and realistic. The following sections propose improvement priorities for moving from

one maturity level to the next.

5.1. From Initial to Managed: Establishing the Basic Governance Framework

Institutions at the Initial level usually face fragmented and reactive management. The priority is to move from disorder to basic order by obtaining leadership support, assigning responsible departments and staff, drafting foundational policies, providing entry-level digital training, acquiring essential hardware and software, and piloting digitization or electronic records projects. Through these actions, an institution can build the basic conditions for digital archives management within a limited period and cross the threshold of the Managed level.

5.2. From Managed to Defined: Organization-Wide Implementation and Standardized Management

After reaching the Managed level, digital archives management has usually been launched in selected areas but is not yet systematic. Progression to the Defined level requires organization-wide rollout. Institutions should refine the policy and standards system, extend digital archives management to all relevant departments and archival categories, deploy an integrated archival management information system, cultivate compound archival and IT talent, and strengthen regular inspection and assessment. These measures help transform local pilots into institutionalized and standardized management.

5.3. From Defined to Quantitatively Managed: Introducing Metrics and Continuous Improvement

At the Defined level, management is relatively standardized, but further improvement requires a shift from experience-based management to data-driven management. Institutions should establish quantitative indicators such as accession timeliness, metadata completeness, utilization rates, user satisfaction, system response time, and security event frequency. Automated data collection, regular analysis, feedback meetings, PDCA cycles, and quantitative security monitoring should be introduced. Once data-driven decision-making and continuous improvement become routine, the institution has entered the Quantitatively Managed level.

5.4. From Quantitatively Managed to Optimizing

Advancing to the Optimizing level means that archival management demonstrates sustained learning, evidence-based innovation, and sectoral contribution rather than simply adopting new technologies. Institutions may explore artificial intelligence classification, natural language processing for knowledge mining, blockchain-based evidence preservation, knowledge graphs, mobile services, open data initiatives, and decision-support functions. Each application should be justified by a defined archival problem and evaluated against measurable value, data quality, authenticity, privacy, security, explainability, human oversight, cost, and long-

term preservation requirements. Technologies that lack demonstrated value or adequate risk controls should not raise the maturity rating. Institutions should also summarize validated practices, participate in standards development, strengthen peer benchmarking, and build resilience against technological, security, and organizational risks.

6. Conclusion

Digital technology is transforming the ecology of archival management and making it necessary to evaluate institutional capability from a dynamic developmental perspective. This study constructs a digital archives management maturity model with five levels and six capability domains, and it proposes a staged pathway for maturity enhancement. The model provides a common language for archival institutions to assess their current status, identify capability gaps, and plan targeted improvement actions. Its value lies in shifting assessment from one-time compliance certification to continuous capability development.

The proposed model should be interpreted as a preliminary conceptual and practice-oriented framework designed primarily for public archives, institutional archive rooms, and university archives. Its use in libraries, museums, or other memory institutions requires contextual adaptation. The model's practical value and measurement quality remain to be tested through expert consultation, pilot application, inter-rater assessment, and empirical validation across institutions of different types and resource levels. Future research should refine indicator definitions, thresholds, domain weights, and evidence requirements, compare the conservative lowest-domain rule with alternative aggregation methods, and develop digital tools for transparent self-assessment and benchmarking.

Author Contributions

Y.Y. was primarily responsible for writing and revising the manuscript. L.L. provided research guidance. Both authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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