The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 4 | Issue 2 | February 2026
ISSN: 2583-973X (Online), SJIF IF: 5.6
Website: www.theacademic.in

Web 3.0: Empowering Libraries through Semantic and Decentralized Innovation

Satender Kumar Verma

[1] Research Scholar, Department of Library and Information Science, University of Delhi, Delhi-110007

Email: satenderk118@gmail.com; ORCID ID 0009-0009-6546-2357

Rohit Kumar

[1] Research Scholar, Department of Library and Information Science, University of Delhi, Delhi-110007

Email: rohitkrtank@gmail.com; ORCID ID 0009-0006-0417-7200

DOI : https://doi.org/10.5281/zenodo.18884617

ARTICLE DETAILS

Research Paper

Accepted: 20-02-2026

Published: 10-03-2026

Keywords:

Web 3.0, Library 3.0, Semantic Web, Decentralization, Intelligent Libraries

ABSTRACT

This paper examines the development of the World Wide Web from the Web 1.0 (static read-only) to Web 2.0 (interactive and participatory) and finally to Web 3.0 (semantic, intelligent, and decentralized) within the framework of library and information science. The paper describes each generation of the web, identifies the major elements of Web 3.0, such as the Semantic Web, artificial intelligence, blockchain, decentralization, interoperability, and user data ownership, and analyzes their benefits (such as improved discovery, personalization, and privacy) and drawbacks (such as complexity, scalability, and resource intensity). The paper shows how these developments make it possible for libraries to be proactive and user-driven knowledge environments. In the future, Web 3.0 will enable libraries to provide more intelligent and balanced services through intelligent systems and decentralized access. This paper argues that the adoption of Web 3.0 will help libraries play a more important role in the data-driven world.

1. INTRODUCTION

In the current scenario the World Wide Web has a create impact in terms of information sharing, and accessing, there are different generation of web 1.0,web 2.0 and web 3.0 in every generation of web it

become static to interactivity and play a great role in terms of satisfy the information need of the user community and the user engagement. There are many examples of the "Web 2.0 brought about interactivity, user content, and social collaboration, which allowed the adoption of technologies such as blogs, wikis, social media integration, and collaborative tagging, known as Library 2.0, to engage communities and provide participatory services" (Balaji et al., 2018).

As we enter the mid-2020s, the "next generation" of the World Wide Web, or Web 3.0, also known as the Semantic Web or the Decentralized Web, is on the horizon. This new generation of the web will be characterized by machine-readable data, artificial intelligence (AI), linked open data, blockchain, and user-centric decentralization. Web 3.0 will allow for intelligent and semantic information processing, where computers will be able to comprehend meaning, context, and relationships, as opposed to simple keyword searches. This will allow users to have more control over their data, provide better privacy through decentralized networks, and facilitate immersive technologies like augmented reality (AR), virtual reality (VR), and metaverse platforms (Ramteke, 2024; Thakur et al., 2025).

In the library science, Web 3.0 is referred to as Library 3.0, a paradigm shift in which the library is transformed into an intelligent, seamless knowledge network. Semantic search facilitates accurate and contextually aware discovery, blockchain facilitates trusted digital rights management, rare material provenance tracking, and open resource sharing, AI-powered personalization facilitates predictive recommendation and automated metadata creation, and linked data (such as BIBFRAME) facilitates global interoperability by overcoming barriers (Parvin, 2025; Balaji et al., 2018). The current technology status has gained immense acceptance in academic libraries, especially in semantic platforms, cloud analytics, and interactive resources such as VR collections and 3D printing in maker spaces, even in developing countries (various studies in 2024 on comparative analyses in Philippine academic libraries, reflecting great service integration).

Despite the challenges of infrastructure costs, the absence of skills among librarians, the challenge of bias in AI, and the challenge of the digital divide, Web 3.0 positions the library as the ethical guardian of decentralized and intelligent knowledge in the era of AI dominance. This new development not only redefines the role of the library but also reaffirms the role of the library in providing innovative access to knowledge in the era of technological advancements (Gujral, recent library analysis on the evolution of Library 4.0 from the Web 3.0 paradigm).

2. LITERATURE REVIEW

Web 3.0 represents a revolutionary shift towards the creation of a decentralized, semantic, and intelligent web technology, which is transforming conventional academic and school libraries into Library 3.0 spaces. These spaces emphasize the use of linked data, semantic interoperability, artificial intelligence (AI), and blockchain technology to enhance resource discovery, metadata management, and user experience. Academic libraries are using semantic search software, AI-powered predictive recommendation software, and blockchain-based provenance software to enhance transparency, privacy, and secure transactions (Diaz, 2024; Ramteke, 2024; Ogunmodede & Ebijuwa, 2025). This helps in realizing borderless and context-aware access to information and positioning libraries as facilitators of intelligent knowledge environments.

Other emerging technologies include virtual reality resources and decentralized platforms that support collaboration and user-managed data environments. However, their implementation is hindered by differences in regions and institutions, with infrastructure and human capacity being a significant bottleneck (Bhandari, 2025). Additionally, it has been found that the competency level of university community members regarding Library 3.0 is still low, and this is influenced by demographic and behavioral factors, thus requiring targeted training in semantic technologies and technical Web 3.0 tools (Thakur et al., 2025). In conclusion, although there still challenges in adopting the technology, Web 3.0 technologies have great potential in improving service delivery, privacy, & innovation in the modern library.

3. OBJECTIVES OF THE STUDY

3.1 To explore the idea of Web 3.0 in library science.

3.2 To determine the trends of Web 3.0 technologies in libraries.

3.3 To analyze the advantages and disadvantages of implementing Web 3.0 in library services.

4. METHODOLOGY

This study uses qualitative descriptive research design, which is grounded on a literature review approach. The study is carried out by examining and interpreting the published scholarly articles, review paper, journal articles, and academic reports on Web 3.0 in the field of library science.

The literature on Web 3.0 in library science is the gathered from academic databases such as Google Scholar, Research Gate, and academic journals using keywords such as “Web 3.0,” “Library 3.0,”

"blockchain in the libraries," "semantic web," and "AI in the libraries." Only recent literature is considered for the purpose of analysis of the trends.

The articles are examined to determine the key themes, trends, advantages, disadvantages, and skill sets required for the implementation of Web 3.0 in libraries. The results of the study are grounded on the comparison, interpretation, and synthesis of the literature.

5. SCOPE AND LIMITATIONS

This paper aims to explore Web 3.0 as a new trend in library science. It discusses important topics like the application of semantic web technology, artificial intelligence, blockchain, and the concept of decentralized systems in changing conventional libraries to Library 3.0.

The paper is restricted to scholarly articles, review papers, and academic sources on Web 3.0 in libraries. The paper discusses trends, advantages, difficulties, and requirements of librarians in the context of existing literature. The paper concentrates on academic and educational libraries and the latest trends in the digital age.

6. EVOLUTION OF THE WEB: DEFINITIONS AND CHARACTERISTICS OF WEB 1.0, WEB 2.0, AND WEB 3.0

The World Wide Web have undergone various generations, which symbolize a paradigm shift in creation, access, sharing, and usage of information. This paradigm shift, from a read-only environment to an interactive environment and now towards a semantic and intelligent environment, has significant implications for the field of library and information science (LIS). In the LIS field, this paradigm shift has transformed libraries from a passive information repository to an active knowledge environment that uses technology for better discovery and service.

6.1 Web 1.0 (Static or Read-Only Web)

Web 1.0, also termed the "static web" or "read-only web," is the first generation of the World Wide Web, which existed from the early 1990s until the mid-2000s (circa 1989-2005). It was essentially an information storage repository where resources were named using Uniform Resource Identifiers (URIs) and displayed in static HTML pages using simple protocols such as HTTP. The information was created and maintained only by webmasters or a few selected experts, and users acted merely as passive recipients who could only "read" or view the information without creating or participating in any way. The characteristic features was one-way communication, limited interactivity, and basic hyperlinks for

navigations. There was no user interaction, no live updating, and the websites resembled electronic brochures or virtual libraries of static documents.

In the context of library and information science, Web 1.0 was present in the form of initial library websites that offered basic institutional information (like rules and timings, and downloadable PDFs) and static Online Public Access Catalogs (OPACs) that facilitated basic keyword searching. These supported one-way communication but did not provide any scope for user feedback, collaboration, or personalization, as in the traditional library paradigm where users were only passive recipients and not active co-producers of knowledge (Khanzode & Sarode, 2016; Awasthi, 2025).

6.2 Web 2.0 (Participatory, Social, or Read-Write Web)

Web 2.0, a term coined by Darcy DiNucci in 1999 and later popularized by Tim O'Reilly and Dale Dougherty around 2004-2005, represents the shift towards a "participative social web" or "read-write web." It represented a paradigm shift from consumption to participation, using tools such as AJAX, blogs, wikis, RSS feeds, social networking sites, tagging, and folksonomies. Users were transformed from consumers to producers of content, facilitating two-way communication, collective intelligence, and community-driven sites. The web was transformed into a collaborative platform, with a focus on user-generated content, social networking, and dynamic updating. O'Reilly summed it up as "harnessing network effects where applications get better as more users adopt them, emphasizing the 'architecture of participation'" (O'Reilly, 2005).

In the context of libraries, this period led to the emergence of Library 2.0, where library services became interactive and user-focused. These include social cataloging tools (such as user tags, ratings, and reviews in OPACs), virtual reference services through chat or instant messaging, library blogs and podcasts for outreach services, incorporation with social networking sites, and collaborative tools such as wikis for knowledge sharing. This led to increased user participation, where users became active producers and helped create folksonomies in addition to controlled vocabularies. (Miranda et al., 2010; Awasthi, 2025; Khanzode & Sarode, 2016).

6.3 Web 3.0 (Semantic, Intelligent, or Decentralized Web)

Web 3.0, also known as the “executable web,” “semantic web,” or “Web of data,” began to appear in the 2010s and is still in development. The concept was coined by John Markoff in 2006 as a smart web that leverages artificial intelligence, machine learning, and data structuring. At its foundation is the Semantic Web concept put forth by Tim Berners-Lee, which seeks to make the web’s data machine-readable and

comprehensible using standards such as RDF (Resource Description Framework), ontologies, linked data, and metadata formats. This helps computerized systems to process, link, and conclude data from different applications, not only in documents but also in creating a global and connected database. Other features include decentralization (through blockchain and peer-to-peer networking for data management and privacy), personalization, context awareness, and AI integration for intelligent recommendations. Users get more control over their data, with the web enabling "reading, writing, and owning" instead of relying on third-party services.

In the field of library and information science, Web 3.0 facilitates the realization of Library 3.0 or "smart libraries" due to the presence of semantic search engines, "linked open data" (such as BIBFRAME, the next generation of MARC records), AI-driven recommendation systems in OPACs, personalized discovery systems, and ontologies. It also facilitates context-aware services, researcher identity management (through linked data profiles), and the possibility of decentralized repositories where users have control over their own borrowing history or contribution to knowledge. This version overcomes the shortcomings of the earlier versions by making information more discoverable, reusable, and processable by machines, thus opening the way for proactive and intelligent library environments (Awasthi, 2025; Khanzode & Sarode, 2016; Miranda et al., 2010; Berners-Lee et al., 2001).

The evolution from Web 1.0 (content-driven, producer-focused) to Web 2.0 (user-driven, participatory) to Web 3.0 (data-driven, machine intelligent, and user-controlled) marks the evolution towards increased interoperability, intelligence, and empowerment. In context of LIS, this evolution marks the need for libraries to harness technology for enhancing accessibility, preserving knowledge, & facilitating inclusive information provision, thus addressing challenges of the data privacy, standardization and digital divides.

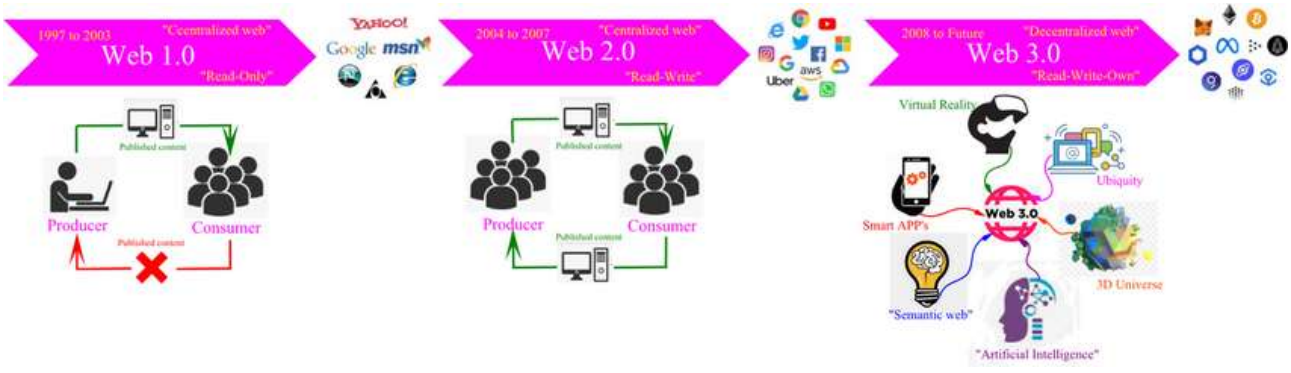


Figure 1: The Changing Face of the Internet: Journey from Web 1.0 to Web 3.0 (Nath, 2022)

7. COMPONENTS OF WEB 3.0

Web 3.0, or the Semantic Web, Intelligent Web, or Decentralized Web, marks a revolutionary shift from the earlier versions by combining the best of various technologies to make the internet more intelligent, interconnected, user-friendly, and autonomous. Unlike Web 1.0 (static content) and Web 2.0 (user-generated content and social media), Web 3.0 focuses on machine-readable data, decentralization, and intelligence to facilitate automated reasoning, personalization, and secure peer-to-peer communication without the need for intermediaries.

In the context of library and information science (LIS), these elements enable the creation of Library 3.0, or intelligent and proactive libraries that use semantic metadata for enhanced discovery, linked open data for interoperability, AI for personalization, and new decentralized architectures for user-controlled scholarly profiles and privacy-friendly services.

The salient features of Web 3.0 are well articulated below, based on the best of classic and contemporary literature:

7.1 Semantic Web

The underlying foundation of Web 3.0, which allows machines to interpret and process web data in a meaningful way using structured data concepts, ontologies, and linked data approaches. Technologies used include Resource Description Framework (RDF), Web Ontology Language (OWL), and SPARQL query languages, as well as linked open data.

In LIS, it facilitates better metadata formats (for example, the shift from MARC to BIBFRAME), semantic searching in digital repositories, and better resource discovery (Berners-Lee et al., 2001; Gan, 2023).

7.2 Decentralization

Decentralizing control from centralized servers and platforms to peer-to-peer networks, mainly through the use of blockchain technology. Data and applications are replicated on multiple nodes instead of being hosted on centralized servers, making it less vulnerable to single points of failure, censorship, and the need for intermediaries. This allows for trustless system where transactions and interactions take place without the need for the trusted third parties.

In context of libraries, this makes it possible to have decentralized repositories, user-controlled data (such as individual reading histories or researcher profiles), and blockchain-based provenance systems for digital collections (Gan, 2023; Perboli, 2026).

7.3 Artificial Intelligence (AI) and Machine Learning

AI supports intelligents processing, natural language understanding, predictive modeling, and personalization. Together with the semantic strengths, it helps build autonomous agents, recommendation systems, and adaptive interfaces that learn from user behavior and context.

In the library context, AI supports personalized discovery systems, reference chatbots, automated metadata generation, and predictive analytics for collection development (Gan, 2023; Expert.ai, 2022).

7.4 Blockchain and Related Technologies

Distributed ledger technologies offer immutability, transparency, and secure transactions. The necessary building blocks include smart contracts (self-executing contracts), value transfer cryptocurrencies/tokens, non-fungible tokens (NFTs) for unique digital assets, and decentralized autonomous organizations (DAOs) for the governance.

The technology can be applied in a library setting for digital lending, NFT-based rare books, or decentralized academic publishing to ensure authenticity and ownerships (McKinsey & Company, 2023; Perboli, 2026).

7.5 Interoperability and Connectivity

Seamless integration between systems via open standards, linked data, and protocols that allow data to move freely between applications and platforms. This includes Web Assembly for efficient execution and APIs for cross-chain compatibility.

In LIS, it encourages global linked data ecosystems that the support federated searches and sharing of resources between institutions (Gan, 2023).

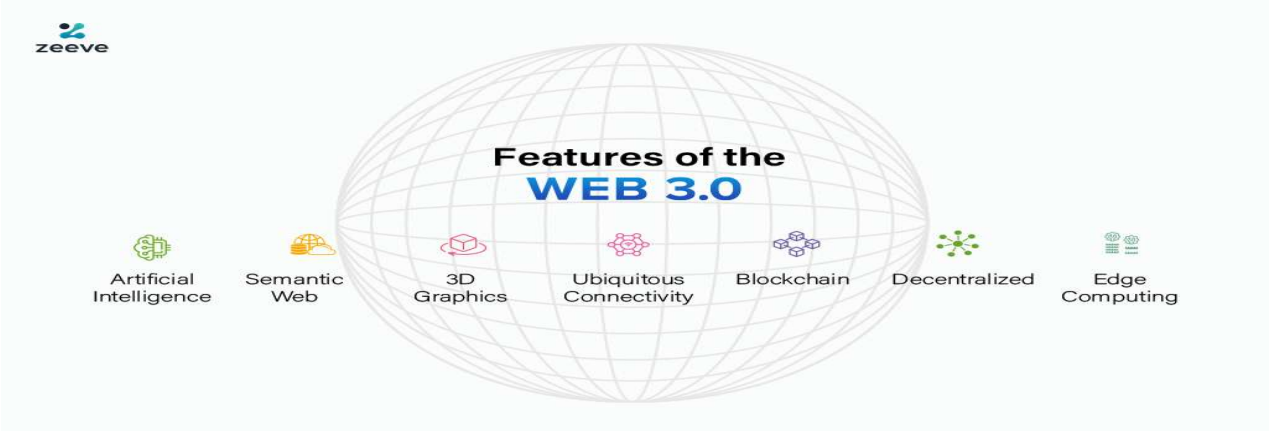
7.6 User Empowerment and Data Ownership

Autonomy for data is enabled for users through self-custody wallets, privacy tools, and data monetization or control. This is not akin to the platform-centric paradigm of Web 2.0.

Talking about libraries, this enables privacy-centric tools, user-controlled researcher identities using decentralized identifiers, and equitable access plans (Shardeum, 2022; Expert.ai, 2022).

Each of these building blocks is interlinked, and the Semantic Web is the meaning layer, AI is the intelligence layer, blockchain is the trust and ownership layer, and decentralization is the equitable distribution layer. These building blocks enable the construction of an "executable" web where data is not only consumed but also reasoned with, personalized, and owned by users.

Talking about libraries, the use of these building blocks enables the shift from passive information dissemination to intelligent, inclusive, and secure knowledge spaces, but scalability, standardization, and



digital literacy are concerns (Awasthi, 2025; Khanzode & Sarode, 2016).

8 ADVANTAGES AND DISADVANTAGES OF WEB 3.0 IN LIBRARY AND INFORMATION SCIENCE

Web 3.0 have the potential to transforms the library through semantic technologies, decentralization, and AI, making intelligent user-centric services possible (Library 3.0). At the same time, it also poses challenges in the adoption process.

8.1 Advantages

Semantic search and resource discovery: Machine-readable data is using RDF, ontologies, and linked open data enables more accurate and context-aware searches, outperforming keyword-based search systems (Berners-Lee et al., 2001; Gan, 2023).

Intelligent and personalized services: AI-powered recommendation systems, adaptive interfaces, and predictive analytics allow for personalized discovery, automated metadata creation, and proactive user support (Miranda et al., 2010; Gan, 2023).

Decentralization and user data control: Blockchain technology is enables secure and privacy-friendly repositories, trusted provenance for digital resources, and user-managed scholarly identities, diminishing the need for centralized platforms (Perboli, 2026; Awasthi, 2025).

Enhanced collaboration and interoperability: Linked data infrastructures enable federated searches and worldwide resource sharing, promoting equitable knowledge access (Khanzode & Sarode, 2016; Gan, 2023).

8.2 Disadvantages

Complexity and technical challenges: The adoption of semantic standards, blockchain, and AI is highly complex and technically challenging for most libraries (Gan, 2023; Miranda et al., 2010).

Scalability and performance problems: Blockchain technology is prone to slow transaction processing, high transaction costs, and low transaction capacity, making it unsuitable for real-time applications in libraries (Gan, 2023).

Resource intensity and digital divide: High computational requirements, power consumption, and costs widen the digital divide, especially in resource-poor libraries (Awasthi, 2025).

Privacy, security, and standardization concerns: Although promising decentralization, new technologies are vulnerable to data security risks, lack of standards, and metadata inconsistencies (Khanzode & Sarode, 2016; Gan, 2023).

9 FUTURE PROSPECTS OF WEB 3.0 IN LIBRARY AND INFORMATION SCIENCE

The future of Web 3.0 will transform libraries into truly intelligent, decentralized, and user-powered knowledge systems! The future looks bright as libraries leverage semantic intelligence, AI, and blockchain to transform information access and preservation.

9.1 Libraries will offer hyper-personalized and contextually aware discovery systems through the use of advanced AI and semantic ontologies, accurately predicting user needs with unexampled accuracy and turning passive discovery into proactive knowledge experiences! (Gan, 2023; Awasthi, 2025)

9.2 Decentralized storage and blockchain technology will empower users to have complete control over their data, facilitating secure, verifiable scholarly activity, tamper-proof digital lending, and censorship-free collections that promote global equity! (Perboli, 2026; Gan, 2023)

9.3 Linked open data systems will reach critical mass in terms of interoperability, enabling effortless federated searches across institutions globally and opening up massive, machine-actionable knowledge networks for collaborative research discoveries! (Berners-Lee et al., 2001; Awasthi, 2025)

9.4 Smart libraries integrated with AI will automate metadata generation, predictive collection management, and immersive virtual experiences, turning libraries into dynamic innovation and lifelong learning centers! (Gan, 2023; Miranda et al., 2010)

These inspiring innovations are poised to transform libraries as dynamic pillars of an inclusive and intelligent digital future.

10 CONCLUSION

In summary, the evolution from Web 1.0 to Web 3.0 is a paradigm shift in the field of library and information science, from passive information dissemination to active engagement and now towards semantic, intelligent, and decentralized networks. Web 3.0, with its constituents of the Semantic Web, AI, blockchain, and decentralization, assists libraries in providing improved discovery, personalized experiences, improved interoperability, and user control over data. Although the advantages include improved resource access, privacy, and collaboration, challenges still exist in terms of technological complexity, scalability, resource intensity, and standardization. As libraries implement these technologies, they must overcome challenges such as training needs and digital divides to reap the maximum benefits. By implementing Web 3.0, libraries can become proactive and equal facilitators of knowledge in a data-driven world, ensuring their continued relevance in a rapidly changing technological environment.

REFERENCE

- Awasthi, R. (2025, November 22). The digital journey of libraries: Tracing service evolution across web generations (1.0 to 5.0). LibCognizance. https://www.libcognizance.com/2025/11/explore-technological-shifts-from-web-1.html
- Balaji, B. P., Vinay, M. S., Shalini, B. G., & Raju, J. S. M. (2018). An integrative review of Web 3.0 in academic libraries. Library Hi Tech News, 35(4), 13-17.
- Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic web. Scientific American, 284(5), 34–43.

- Bhandari, L. (2025). *Transition from Web 2.0 to Web 3.0*. International Journal of Science and Advanced Technology. https://www.ijsat.org/papers/2025/1/2554.pdf
- Diaz, A. K. (2024). Academic library implementation of Web 3.0: A comparative analysis. *Psychology and Education: A Multidisciplinary Journal, 22*(3). https://ejournals.ph/article.php?id=27707
- Expert.ai. (2022, April 8). The 8 defining features of Web 3.0. https://www.expert.ai/blog/web-3-0
- Gan, W. (2023). Web 3.0: The future of internet. Proceedings of the 2023 7th International Conference on Information System and Data Mining, 1–6. https://doi.org/10.1145/3600085.3600090
- Khanzode, C. A., & Sarode, R. D. (2016). Evolution of the world wide web: From web 1.0 to 6.0. International Journal of Digital Library Services, 6(2), 1–11.
- Markoff, J. (2006, November 12). Entrepreneurs see a web guided by common sense. The New York Times. https://www.nytimes.com/2006/11/12/business/12web.html
- McKinsey & Company. (2023, October 10). What is Web3 technology (and why is it important)? https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-web3
- Miranda, G. F., Gualtieri, F., & Coccia, P. (2010). How the new web generations are changing library and information services. Medical Reference Services Quarterly, 29(2), 132–145. https://doi.org/10.1080/02763861003723200
- Nath, K. (2022). Evolution of the Internet from Web 1.0 to Metaverse: The good, the bad and the ugly. TechRxiv. https://doi.org/10.36227/techrxiv.19743676
- Ogunmodede, T. A., & Ebijuwa, A. S. (2025). Blockchain technology as a tool for effective library services in a digital era. *International Journal of Library and Information Science Studies*. https://eajournals.org/ijliss/wp-content/uploads/sites/68/2025/01/Blockchain-Technology.pdf
- O'Reilly, T. (2005). What is Web 2.0: Design patterns and business models for the next generation of software. O'Reilly Media. https://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html
- Parvin, B. (2025). Web 2.0 and Web 3.0: Transforming library services in the digital era. JETIR.
- Perboli, G. (2026). Decentralizing the future: Value creation in Web 3.0 and the Metaverse. PMC. https://pmc.ncbi.nlm.nih.gov/articles/PMC12828255

- Ramteke, S. (2024). *Web 3.0: Evolution of web-based library services*. ResearchGate. https://www.researchgate.net/publication/384827953_Web_30_Evolution_of_Web_-Based_Library_Services

- Shardeum. (2022, November 14). 10 key features of Web 3.0 technology. https://shardeum.org/blog/what-are-the-features-of-web-3-0

- Thakur, R. A., Sharma, D., Gupta, S., & Gul, S. (2025). Library 3.0 competencies of importance: Assessing the impact of variables of users' readiness in university library settings. *Social Sciences & Humanities Open, 12*, Article 101941. https://doi.org/10.1016/j.ssaho.2025.101941

- Zeeve. (2022, September). Distinctive components of the Web 3 technology [Infographic]. https://www.zeeve.io/blog/distinctive-components-of-the-web-3/