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Utilizing Modern Technology for the Preservation of Ancient Manuscripts and Rare Books: The Digitization Project at King Abdulaziz Complex for Endowment Libraries as a Model



Neue Technologien für die Erhaltung von historischen Manuskripten und Büchern: Das Digitalisierungsprojekt am König-Abdulaziz-Komplex für Stiftungsbibliotheken als Beispiel

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Abstract: Preserving rare manuscripts through digitization has become an essential part of efforts to safeguard cultural heritage in the digital age. These fragile or deteriorating documents face the risk of damage and loss, and information technology provides an effective solution to protect these valuable resources for future generations. It not only helps preserve the originals, but also makes historical knowledge more accessible and flexible. This study adopted a descriptive and analytical approach to present the experience of the King Abdulaziz Complex for Endowment Libraries in digitizing manuscripts, rare books, and 3D-objects. The study relied on observations and field visits to the digitization lab at the King Abdulaziz Complex for Endowment Libraries. Most of these libraries contain a unique collection of manuscripts and rare documents of historical significance. The study resulted in many findings, the most notable of which is the completion of the digitization of 13,411 manuscripts, while 2,280 manuscripts still require conservation. The total number of digitized rare books is 7,644. This study demonstrates that digitization represents a modern and effective technical means for the preservation of ancient manuscripts and rare books, facilitating access and sharing, long-term

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preservation, and significantly contributing to the preservation of human cultural heritage.

Keywords: King Abdulaziz Complex for Endowment Libraries; manuscript digitization; historical heritage; Saudi Arabia; Madinah; information technology

Zusammenfassung: Im digitalen Zeitalter ist die Erhaltung seltener Manuskripte durch Digitalisierung ein wesentlicher Bestandteil der Bemühungen zum Schutz des kulturellen Erbes geworden. Diese fragilen und durch andauernde Alterungsprozesse bedrohten Dokumente sind dem Risiko der Beschädigung und des Verlusts ausgesetzt, und die Informationstechnologie bietet eine effektive Lösung, um diese wertvollen Ressourcen für künftige Generationen zu schützen. Dies trägt nicht nur zur Erhaltung der ursprünglichen Schriftstücke bei, sondern macht auch historisches Wissen leichter zugänglich und flexibel. Diese Studie wählte einen deskriptiven und analytischen Ansatz, um die Erfahrungen am König-Abdulaziz-Komplex für Stiftungsbibliotheken bei der Digitalisierung von Manuskripten, historischen Büchern und anderen Objektgruppen darzustellen. Die Studie stützte sich auf Beobachtungen und Vor-Ort-Besuche im Digitalisierungslabor des König-Abdulaziz-Komplex für Stiftungsbibliotheken. Die meisten dieser Bibliotheken enthalten eine einzigartige Sammlung von Manuskripten und seltenen Dokumenten von historischer Bedeutung. Die Studie führte zu zahlreichen Ergebnissen, von denen das bemerkenswerteste der Abschluss der Digitalisierung von 13,411 Manuskripten ist, während 2,280 Manuskripte noch restauriert werden müssen. Die Gesamtzahl der digitalisierten historischen Bücher beträgt 7,644. Diese Studie zeigt, dass die Digitalisierung ein modernes und effektives technisches Mittel für die Bewahrung alter Handschriften und historischer Bücher darstellt, das den Zugang und die gemeinsame Nutzung sowie die langfristige Bewahrung erleichtert und wesentlich zur Erhaltung des menschlichen Kulturerbes beiträgt.

Schlüsselwörter: König-Abdulaziz-Komplex für Stiftungsbibliotheken; Digitalisierung von Manuskripten; historisches Erbe; Saudi-Arabien; Medina; Informationstechnologie

1 Introduction

The King Abdulaziz Complex for Endowment Libraries in Madinah is one of the most important cultural institutions in the Kingdom of Saudi Arabia, housing a large and diverse collection of rare manuscripts and precious books. Established by Cabinet Resolution No. 389 on June 20, 2016, this esteemed institution operates under the guidance of a Board of Trustees, led by the Royal Highness, the Prince of

Madinah Region, and is organizationally connected to the Prime Minister. Its mission is both noble and ambitious: to safeguard and manage the Kingdom's endowment libraries and rare collections with the highest standards of professionalism, ensuring that these treasures are accessible to all. For a long time, the ancient manuscripts and rare books at the King Abdulaziz Complex for Endowment Libraries were confined to their storages, and over time, many of them suffered damage. There was a necessity for a supportive factor to preserve the physical integrity of these manuscripts.

As Dutta (2019) and other scholars have highlighted, a global trend is emerging toward empowering nations to reclaim control over their historical records and cultural heritage. In alignment with this movement, Saudi Arabia is ensuring that the stewardship of its history and culture is managed domestically, promoting a deeper sense of ownership, authenticity, and responsibility among its people. Future research will examine the evolving role of national capacities in archival practices to gain a better understanding of the long-term impact of these efforts on cultural preservation.

With the advancement of technology and the growing need to preserve this invaluable heritage, digitization has emerged as a modern and effective solution to safeguard manuscripts, rare books, and 3D-artifacts, ensuring their availability for future generations. Digitization facilitates the accessibility and transfer, retaining all the primary features for beneficiaries, researchers, and scholars in the field of heritage (Jones 2019). For researchers worldwide, the ability to access these manuscripts online has removed the need for travel to Madinah, thus opening the Complex's valuable contents to a much larger audience. Digitization offered an optimal solution to many problems associated with handling manuscript heritage, which has been a point of interest for specialists for many years, such as providing access to manuscripts at any time and from anywhere to a larger number of beneficiaries, while preserving the original manuscript from damage due to direct handling. Additionally, it facilitated the search processes in the extensive and diverse volumes of manuscript heritage books, saving time and effort for researchers.

While digitization offers a good opportunity to preserve and to help access the content of documents like text, images, and metadata, there are still limitations to the method (Van Veenendaal 2018). Digitization struggles to capture intangible aspects, such as the tactile feel, material authenticity, or cultural significance tied to physical objects. Additionally, some knowledge forms – such as oral traditions or experiential learning – may resist digitization, risking misrepresentation or loss of meaning. The study highlights the importance of carefully identifying which essential properties must be preserved to maintain the authenticity and cultural value of digital reproductions.

The digitization of historical heritage at the King Abdulaziz Complex for Endowment Libraries is one of the pioneering projects in the field of digital libraries. The interest in manuscripts has been increasing day by day due to their artistic and aesthetic characteristics, which distinguish them from other informational media, in addition to their historical value. The developments in the field of information transfer, processing, and broadcasting lead us to discuss the real fate of manuscripts, especially considering the ongoing conflict between traditional paper and electronic information sources. Ancient manuscripts and rare books at the King Abdulaziz Complex for Endowment Libraries face significant challenges related to preserving them from damage and loss, as well as the difficulty of access for researchers and interested parties worldwide. Despite efforts to preserve these cultural treasures, traditional methods face several limitations, such as the high degree of damage resulting from the aging of paper materials, exposure to harmful environmental factors, and potential threats from natural disasters. Given the importance of manuscripts in scientific and historical research, the King Abdulaziz Complex for Endowment Libraries has an exceptional and distinguished experience in digitizing and cataloging manuscripts and rare books, making them available to researchers through the digital repository.

Numerous projects and studies have contributed to understanding the processes, techniques, and challenges involved in digitization (Brown 2020). The Bibliotheca Alexandrina Manuscript Digitization Project, launched in 2003, was a groundbreaking initiative in the Arab world. It not only safeguarded rare manuscripts through advanced digital imaging but also introduced virtual browsing software, offering users an interactive experience akin to handling the original documents (Hussein 2016). In Algeria's Touat Region, a significant project focused on cataloging and digitizing regional manuscripts, highlighting the importance of local and international partnerships in preserving cultural heritage (Moulay 2014). The Juma Al Majid Center in Dubai also undertook a major digitization project, making a large collection of manuscripts accessible online. This initiative represented a milestone in the use of modern technology to protect historical documents, reinforcing the center's dedication to preserving cultural heritage (Abu Farha 2005). Oman's digitization efforts demonstrate a variety of approaches, involving government, private, and individual entities. However, these efforts have faced challenges, including limited resources and insufficient restoration facilities (Al-Hajji 2016).

From a technical standpoint, studies have examined different digitization processes and techniques. For instance, Smith (2018) identifies the essential stages of digitization, including evaluation, imaging, and quality control. Advanced technologies such as multispectral imaging and 3D reconstruction have greatly enhanced the quality of digital archives, uncovering manuscript details that were previously imperceptible to the naked eye. Additionally, researchers have explored virtual

conservation techniques and the application of high-resolution cameras to improve the clarity of fragile or deteriorated manuscripts (Brown 2020; Shabani et al. 2022).

Digital preservation plays a crucial role in ensuring the longevity and accessibility of digital collections. Scholars such as Conway (2017), Green, Kaplish, and Walker (2017), Duffy (2018), and Gupta and Sharma (2017) highlight the importance of establishing robust frameworks that encompass data migration, redundancy, and compliance with international standards. These measures are essential for maintaining the integrity and accessibility of digital files over time. Additionally, the growing adoption of cloud storage has emerged as a key trend, with many institutions leveraging these solutions to enhance the security and preservation of their digital collections.

Despite the progress made, challenges remain. The digitization of fragile manuscripts requires specialized tools and skilled personnel, and the cultural gap between traditional scripts and modern readers poses a threat to the usability of digital documents. Efforts to bridge this gap, such as community activities and educational initiatives, are crucial to ensuring that digitized manuscripts remain relevant and accessible.

The research problem lies in how to effectively apply digitization techniques to preserve ancient manuscripts and rare books at the King Abdulaziz Complex for Endowment Libraries and achieve the maximum benefit from this process. The present study will focus on the following research questions:

- What are the techniques used in the digitization project?
- How can digitization techniques contribute to protecting ancient manuscripts and rare books from damage and loss at the King Abdulaziz Complex for Endowment Libraries?
- What are the basic steps followed in digitizing manuscripts and rare books?
- How does digitization affect the accessibility and usability of manuscripts by researchers?

2 Research Methodology and Tools

This study adopted a descriptive and analytical approach in studying the digitization project of manuscripts, rare books, and 3D-artifacts at the King Abdulaziz Complex for Endowment Libraries in Madinah, Saudi Arabia. The researcher chose this methodology to describe the reality of the digitization project at the Complex. Subsequently, the content analysis method was followed to identify global standards and practices for digitization, understand the techniques used, and determine the essential stages and necessary tasks for digitization. For data collection, the study relied on observations and field visits to the digitization lab at the King Abdulaziz

Complex for Endowment Libraries at its temporary location at the Islamic University. Data analysis was conducted to determine the main stages of the digitization process, evaluate the impact of various techniques, and identify the best practices and standards for digitization and long-term digital preservation. Additionally, a significant amount of data was collected from the Complex's digital repository.

3 Larger Context of the Digitization Project

The project of digitizing manuscripts, rare books, and 3D-artifacts at the King Abdulaziz Complex for Endowment Libraries is one of the key projects aligning with the goals of Saudi Vision 2030. This vision aims to preserve the cultural and historical heritage of the Kingdom using modern technology. This project serves as a model for preserving historical and cultural heritage, ensuring sustainability for future generations, and presenting heritage in innovative ways.

Vision 2030 considers the digitization of cultural heritage as an integral part of its strategy to develop culture and knowledge. By supporting digitization projects, the vision aims to enhance national identity and preserve cultural heritage for future generations. Vision 2030 encourages the use of technology to promote cultural sustainability and achieve excellence in various fields.

A notable feature of this project is that it is implemented by skilled and trained Saudi hands, enhancing the Kingdom's ability to achieve self-sufficiency in technology and heritage preservation. Through continuous training and development of Saudi personnel in digitization and cataloging, a generation capable of preserving heritage in innovative and sustainable ways is being built. Below is the current status of the digitization project.

3.1 Project Overview

The actual work began on October 1, 2022. In June 2021, a specialized lab for the digitization project was completed. The internal network was extended, and servers and storage devices connected to the network were prepared according to international best practices. In June 2021, a 3D scanning workshop was set up, and employees were trained for the digitization project. The project employs 15 staff members: 11 in the digitization department, 2 in the review department, and 2 supervisors. The digitization project consists of three parts: ancient manuscripts, rare books, and 3D-artifacts. A system was established to work in two shifts (morning and evening) to increase the output rate without affecting quality. The estimated number of pages for manuscripts and rare books in the Complex is 11,500,000, and the estimated number

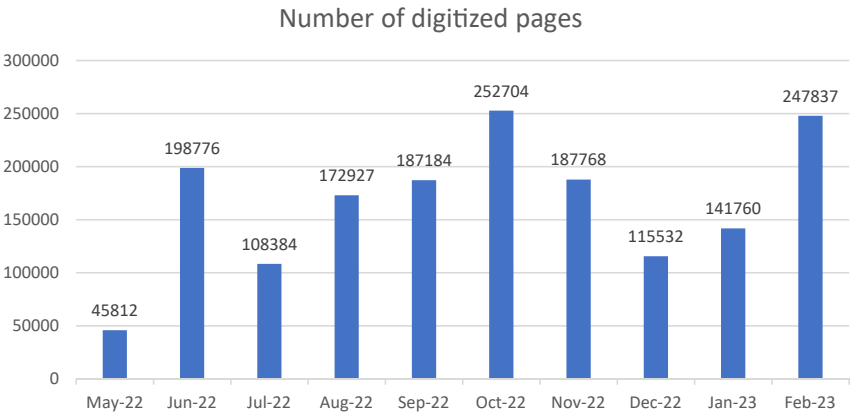


Figure 1: Number of digitized pages monthly.

of volumes in the Complex is 46,000, including 16,000 manuscript volumes and 30,000 rare book volumes. Manuscripts are classified into three categories based on their condition and need for care:

- Grade A: Intensive care: manuscripts in poor condition
- Grade B: Medium care: manuscripts in medium condition
- Grade C: Normal care: manuscripts in good condition

Digitization of all manuscripts and rare books in good and medium conditions is carried out according to their specific care procedures. The digital scanning of manuscripts in poor condition is postponed until they are treated and restored due to the difficulty of working on them without further weakening or damaging them.

Figure 1 shows the monthly progress of digitized pages from May 2022 to February 2023. Starting with a low count of 45,812 pages in May 2022, digitization efforts quickly increased, peaking in October 2022 at 252,704 pages. While there were fluctuations, with a low point in December 2022 (115,532 pages), the project maintained a generally high output. February 2023 marked another productive month, reaching 247,837 pages, indicating consistent growth in the digitization process.

3.2 Digitized Objects and the Digital Repository

As a result of the digitization efforts, the number of digitized volumes in major libraries includes more than 4,500 manuscripts in the Arif Hikmat Library, over 4,500 manuscripts and rare books in the Mahmoudia Library, more than 1,000

manuscripts and rare books in the Rabat Osman Library, over 1,000 manuscripts in the Bashir Agha Library, and more than 1,000 manuscripts and rare books in the Shifa Library, among others. Digitizing manuscripts, rare books, and 3D-artifacts with high quality ranges from 400 to 600 dpi in various sizes up to A1, including a complete studio for 3D photography (Figure 2). Within the project, supervision of all technicians and equipment in the labs has been conducted to ensure that both technical operations and equipment maintenance meet project standards. This includes overseeing all technical aspects, coordinating with technicians, and ensuring the smooth operation of equipment. Additionally, comprehensive data security measures have been implemented by creating backups of project outputs using network-connected storage devices. Training and technical guidance have also been provided to support efficient uploading to the digital repository. Developing the digital repository aims to provide parts of manuscripts, rare books, and 3D-artifacts from the Complex at the highest quality. The digital content in the repository is cataloged using the Dewey Decimal Classification. The digital repository enables users to browse and search the Complex's collections using preservation numbers, titles, subjects, and authors. Currently, parts of the manuscript (beginning, middle, and end) are displayed, and researchers can request complete images of the manuscripts through the Complex's online portal. Additionally, users can zoom in and out on pages to view all details. A total of 59 3D-artifacts were photographed using professional 3D and 2D imaging techniques (Figure 3).

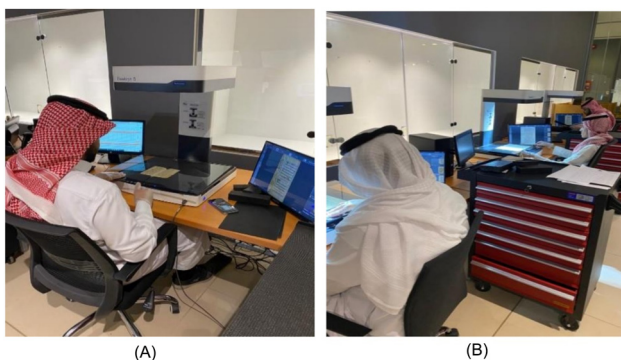


Figure 2: Digitization of manuscripts in various sizes. (A) Digitizing manuscripts in A8 sizes using high-resolution imaging equipment. (B) Digitizing manuscripts in A4 sizes with optimized precision to maintain clarity and quality.

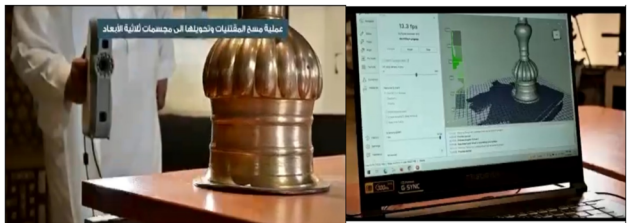


Figure 3: 3D imaging of rare collectibles.

3.3 Total Achievements in Manuscripts and Rare Books

Table 1 provides a detailed overview of the number of manuscripts digitized in the digitization project at the King Abdulaziz Complex for Endowment Libraries. The table lists the endowment libraries and the number of manuscripts digitized in each. The data shows that the total number of digitized manuscripts is 13,411, while 2,280 manuscripts still need conservation treatment.

Table 2 provides a detailed overview of the number of rare books digitized in the endowment libraries at the King Abdulaziz Complex. The table lists the libraries and the number of rare books digitized in each, giving a comprehensive idea of the volume of work completed in digitizing these rare books. The table shows that the

Table 1: Total manuscript achievements.

Library	Number of digitized manuscripts	Library	Number of digitized manuscripts
Arif Hikmat Library	4,606	Rabat Osman Library	683
Mahmoudia Library	2,889	Abdul Qadir Shalabi Library	87
Al-Ihsaniya School Library	112	Sheikh Omar Hamdan Library	120
Al-Jabarti Library	24	Rabat Qura Bash Library	740
Al-Khatini Library	44	Kili Nazari Library	177
Al-Saqzli Library	475	Muhammad Noor Kutbi Library	5
Al-Sada Al-Safi Library	174	Al-Shifa School Library	825
Al-Irfaniya Library	80	Al-Madinah Library	162
Al-Qazaniya Library	127	Holy Quran Library	1,044
Bashir Agha Library	1,037		
Total	13,411 manuscripts	Remaining	2,280 manuscripts needing conservation

Table 2: Total rare book achievements.

Library	Number of digitized rare books	Library	Number of digitized rare books
Mahmoudia Library	1,900	Al-Madinah Public Library	105
Al-Jabarti Library	44	Al-Ma'arif Library	13
Al-Sada Al-Safi Library	287	Rabat Sayyidna Osman Library	104
Al-Saqzli Library	219	Qura Bash Library	199
Sheikh Abdul Qadir Algerian Library	207	Al-Shifa School Library	710
Sheikh Abdul Qadir Shalabi Library	3	Unknown	1,681
Sheikh Ammar Al-Azhar Library	94	Al-Marrakshi Library	644
Sheikh Muhammad Noor Kutbi Library	315	Sheikh Ibrahim Al-Khatini Library	110
Al-Ihsaniya School Library	123	Sheikh Omar Hamdan Library	206
Al-Irfaniya School Library	306	Sheikh Muhammad Khudr	324
		Al-Shanqiti Library	
General repository	1	Kili Nazari Library	49
Total	7,644 rare books		

total number of digitized rare books is 7,644. The numbers vary across different libraries, with the Mahmoudia Library digitizing 1,900 rare books, reflecting the significant efforts made in digitizing these valuable books.

3.4 Technologies Used in the Digitization Project

The digitization lab is equipped with various tools, equipment, and software suitable for each type of information medium in the Complex. Some of the key tools include:

1. **High-resolution scanners**

The digitization lab is equipped with high-resolution scanners that are essential for converting paper manuscripts into digital images with exceptional clarity (Figure 4). These scanners are not only recognized for their high-quality output but also for their speed and ease of use, making them particularly effective in handling sensitive materials.

Key scanners in the lab include:

- **Book Eye 5:** This advanced overhead book scanner is ideal for producing high-quality digital images of books, manuscripts, and various documents due to its exceptional precision. The Book Eye 5 uses a non-contact scanning method, allowing it to handle delicate and bound materials without causing damage. It

supports resolutions up to 600 dpi, delivering detailed, color-accurate images that preserve the authenticity of historical documents and rare books. The scanner also features advanced image processing capabilities, including automatic color correction, skew adjustment, and open-page curvature correction, enhancing image clarity and reducing the need for post-processing.

- **Book2net Profi V2 A2:** The Book2net Profi V2 A2 scanner is a versatile and robust tool ideal for digitizing large documents up to A2 size with high clarity, making it suitable for books, maps, and blueprints. With high-resolution capabilities (up to 600 dpi) and advanced features like auto-cropping, de-skewing, and color correction, it ensures quality and efficiency in scanning.
- The **ET 18 Pro (CZUR)** is a high-quality overhead scanner designed for efficient digitization of books and documents up to A3 size. With an 18-megapixel camera, it captures detailed, vibrant images and includes features like AI-powered page flattening and finger removal for clean scans. It processes pages quickly (1.5 s per page) and supports various formats, including PDF and TIFF, with OCR capabilities for searchable, editable text.
- **Artec Eva:** The Artec Eva is a portable, lightweight 3D scanner designed for scanning medium-sized objects, including sculptures, artifacts, and industrial parts. Renowned for its combination of speed and precision, it is well-suited for applications that require detailed and accurate scans (Figure 3).
- The **Book2net Kiosk** is a fast, easy-to-use book scanner intended for archives. It supports scanning up to A2 size, making it suitable for books and documents. Key features include a touchscreen interface, non-contact scanning to safeguard delicate materials, high-resolution output up to 300 dpi, and image processing options such as auto-cropping and color adjustment. It offers various output formats and uses eco-friendly LED lighting.

The decision-making criteria for selecting specific devices in the digitization process are primarily based on the type, condition, and format of the material being digitized. For instance, scanners like the **Book Eye 5** or **Book2net Profi V2 A2** are preferred for bound volumes, manuscripts, or flat documents because of their ability to capture high-resolution images with minimal handling of the material, which is especially important for fragile items. On the other hand, cameras may be used for three-dimensional objects, artifacts, or items that are too delicate or irregularly shaped to be flattened for a scanner. For example, the **Book2net Profi V2 A2** is ideal for larger items, while the **Book2net Kiosk** excels with smaller, more delicate items due to its high precision. Similarly, the **CZUR ET 18 Pro** is favored for its balance of speed and quality when handling books, especially when large-scale digitization is required. These criteria help ensure that each tool is used in the most efficient and effective way, preserving the quality of the material while minimizing potential damage.

2. **High-resolution digital cameras:** Employed for capturing high-quality digital images of manuscripts, these cameras offer a flexible alternative to traditional scanners, especially when varied imaging requirements are needed. This project uses the **Canon EOS 5DS R** and **Nikon D850**, both recognized for their high-resolution capabilities (50.6 and 45.7 MP, respectively) and ability to capture fine details accurately.
3. **Image editing software:** This software is essential for enhancing the quality of digital images generated during digitization, offering tools for fine-tuning color balance, contrast, and removing imperfections or signs of aging. The project uses **Adobe Photoshop** and **Adobe Lightroom** for detailed adjustments, ensuring precise control over clarity, color fidelity, and overall image quality.
4. **Optical character recognition (OCR) software:** This software is used to transform text within digital images into formats that are both searchable and editable, enhancing accessibility to manuscript content. I noted that the intricacies of Arabic script present significant challenges for OCR, limiting its primary application in this project. Nonetheless, future efforts may consider developing custom OCR solutions and machine learning models specifically adapted for Arabic text.
5. **Format conversion software:** Enables conversion of digital files into formats compatible with online display and use, making it easier to publish and share them.
6. **Content management systems:** Used to manage and organize digital manuscripts and make them accessible to the public online in an organized and easily accessible manner.
7. **Computers and servers:** Used for storing, processing, and displaying digital manuscripts, ensuring their continuous availability for use.
8. **3D imaging software:** Used to create 3D models of manuscripts, adding a new dimension to understanding and studying heritage materials.
9. **Digital transformation system (DTS):** DTS is a comprehensive system designed to track all operations related to the digitization of manuscripts, starting from their inventory and transfer to their archiving. This system uses barcode scanner technology to scan the identifiers of manuscripts and the carts that transport them, ensuring accurate and efficient tracking throughout all digitization stages (Figure 5).

These combined tools contribute to facilitating the digitization process and effectively and sustainably preserving cultural and literary heritage.

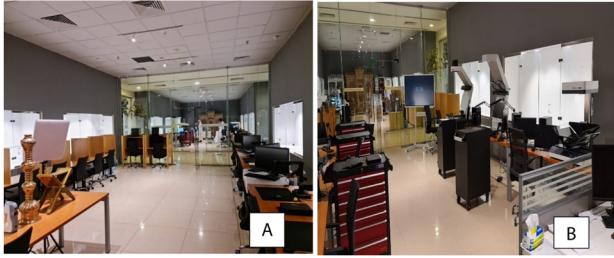


Figure 4: Facilities in the digitization laboratory. (A) Manuscript digitization laboratory equipped with high-resolution scanners for preserving fragile manuscripts with exceptional clarity. (B) Rare book digitization laboratory designed for handling and digitizing rare books with precision and care.



Figure 5: Barcode scanner for scanning manuscript identifiers and inputting them into the tracking system.

3.5 DTS Tracking System Workflow

The digital transformation system (DTS) aims to manage all processes related to tracking the manuscript from its inventory and transfer to archiving. Figure 6 illustrates the DTS tracking system workflow in a flowchart format, detailing the process from inventory to archiving.

The workflow is divided into four key stages:

1. Inventory and documentation:

- Manuscript and transport cart data are entered into the system using a barcode scanner.
- Each cart and manuscript identifier is scanned to ensure precise and comprehensive documentation in the database.

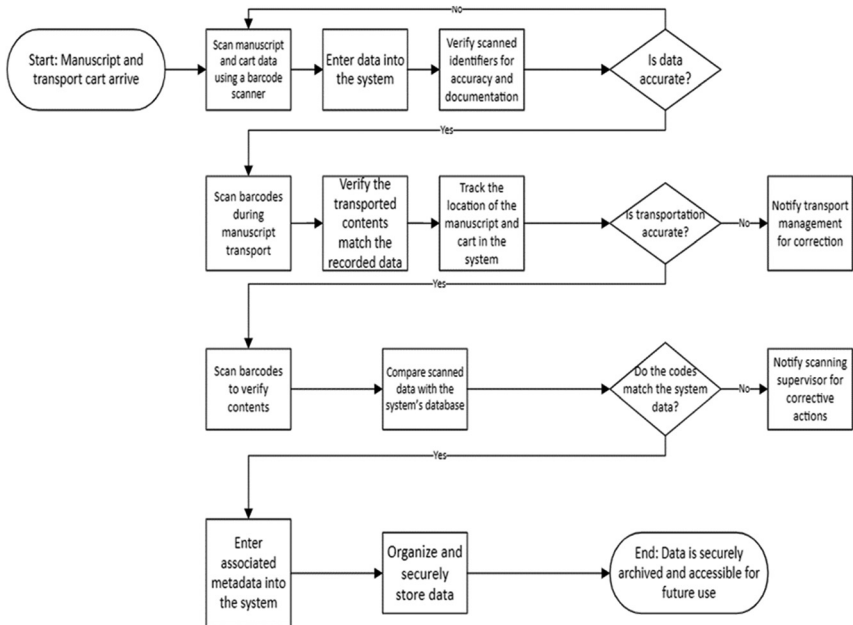


Figure 6: DTS tracking system workflow.

2. Transport of manuscripts:

- The system tracks the transportation of manuscripts by scanning barcodes to verify the accuracy and match the transported contents with the recorded data in the system.
- The system allows tracking the location of each manuscript and the cart it is always on, facilitating transport management and ensuring the safety of the contents.

3. Digital imaging:

- Upon reaching the imaging stage, the contents of the cart are verified using a barcode scanner.
- The system compares the scanned codes with the database to ensure their match with the recorded information.
- If the barcode data do not match the system information, the scanning supervisor is immediately notified to take necessary actions.

4. Digital archiving:

- After digitization, digital images and manuscripts are archived in the system using the metadata associated with each manuscript.

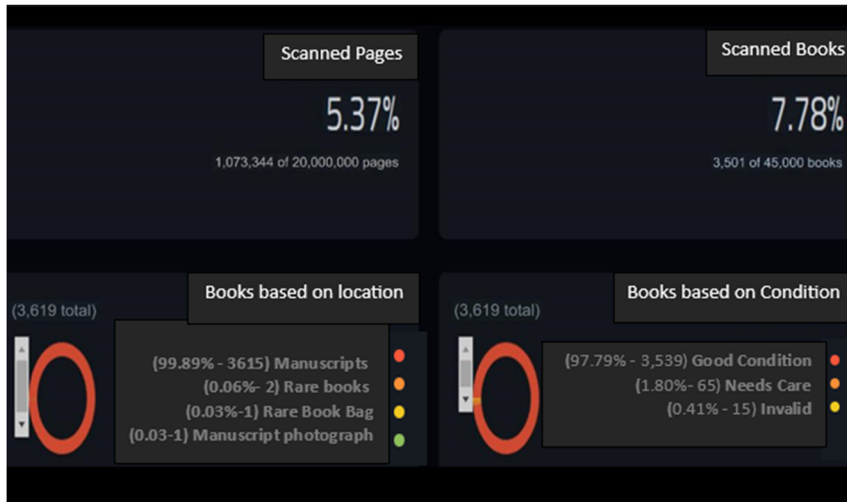


Figure 7: Outputs from the progress tracking program page.

- The system organizes and securely stores the data, making it easy to access and retrieve when needed.

This structured workflow ensures that manuscripts are accurately tracked, digitized, and securely archived, preserving their integrity and facilitating efficient access.

Figure 7 displays the outputs from the progress tracking program page as of October 23, 2021. The figure presents statistical data on the digitization process of books and manuscript pages. It includes four main panels showing the completion rates, distribution, progress percentage of digitization for both pages and books, and the distribution of books based on location and condition, providing a comprehensive overview of the progress of this significant project.

3.6 Basic Steps in Digitizing Manuscripts, Rare Books, and 3D-Artifacts

The field study revealed the basic steps for digitizing rare manuscripts, which involve multifaceted processes requiring careful planning and execution, and they include:

1. Assessment, receipt, and transfer:

- Assess the physical condition and importance of manuscripts to determine the best digitization approach.

- Prepare lists of manuscripts based on priorities and sort them according to their condition, excluding manuscripts in poor condition or those that could be damaged by scanning.
2. **Preparation:**
 - Clean and repair manuscripts as needed.
 - Select the appropriate equipment and settings for digitization.
 3. **Imaging:**
 - Capture high-quality digital images using scanners or specialized cameras.
 4. **Metadata creation:**
 - Create detailed metadata to describe the content, context, and condition of manuscripts.
 5. **Quality control:**
 - Ensure that the digital images meet the required standards for accuracy, color, and completeness.
 6. **Digital storage:**
 - Store digital files in secure and replicated systems to protect them from data loss and ensure long-term access.

3.7 Quality Control in Manuscript Digitization

Quality control plays a crucial role in ensuring that digitized manuscripts accurately capture the intricate details and original characteristics of the materials. The field study underscores the importance of implementing a structured quality control process to maintain high standards of accuracy, clarity, and color consistency, preventing errors or distortions that could affect the visual and informational integrity of the digital copies (Figure 8).

The process begins by defining clear specifications for the final product and establishing a timeline for completion. These measures provide a framework for

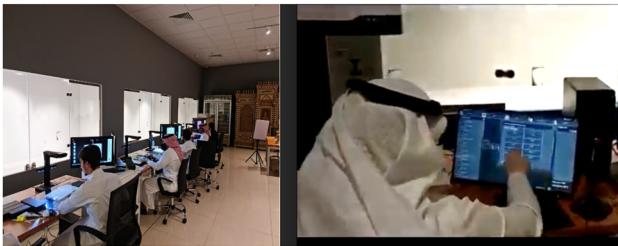


Figure 8: Improving the quality of digital images.

validating progress and addressing any deviations from the plan promptly. Specific criteria are then developed to assess the quality of the digital images, ensuring they meet precise standards for sharpness, detail, and overall accuracy. Key evaluation metrics are also determined to measure the success of the digitization process. These include identifying whether a sample of images or the entire collection will undergo quality control and deciding whether assessments will be performed on-screen or through printed outputs. During these evaluations, specialized tools are employed to adjust elements like color, resolution, dimensions, and noise levels to ensure consistency across the collection. A comprehensive review of the entire project follows, with an initial inspection to identify any broad inconsistencies, such as differences in page brightness or irregular margins. A more detailed, page-by-page examination is then conducted to pinpoint specific errors that require correction. The final step involves a meticulous comparison of the digital versions with the original manuscripts. This comparison ensures that key features, such as color fidelity and text accuracy are preserved, allowing the digital copies to remain faithful to the originals in both appearance and content. Through this structured approach, the digitization process safeguards the authenticity of historical manuscripts while producing high-quality digital versions that can serve as valuable resources for future generations.

3.8 Manuscript Status after Review

The following chart (Figure 9) shows the status of manuscripts after the review process in the digitization project. Manuscripts are categorized into three main categories. The first category, “Accepted,” represents 59 % of the total manuscripts, indicating that a large proportion of manuscripts were accepted after the initial review. The second category, “Rejected,” represents 15 % of the total manuscripts, indicating that a portion of the manuscripts were not accepted and were rejected after evaluation. The third category, “Original Manuscript Review,” represents 26 %

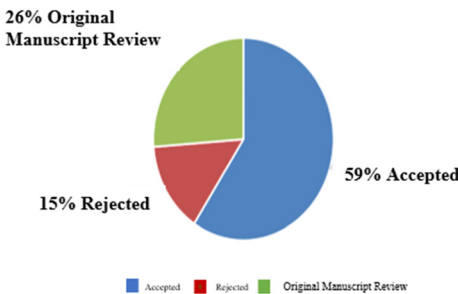


Figure 9: Manuscript status after review.

Table 3: Manuscript status after review.

Manuscript status	Reasons
Rejected	(90 %) Quality is less than 400 dpi (1 %) Significant tilt in images (2 %) Blurry images (7 %) Excessive glare affecting readability
Original manuscript review	Incorrect page sequence Missing pages Incomplete margins on manuscript edges Missing cover at the beginning or end

of the total manuscripts, requiring further reviews and revisions before a final decision on acceptance or rejection is made.

Table 3 presents the different reasons leading to the rejection of manuscripts after the review process. The reasons are classified into two main categories: reasons related to image quality and reasons related to the condition of the original manuscript. The table aims to clarify the specific criteria that influence the acceptance or rejection of manuscripts in the digitization process. This table highlights the importance of adhering to technical and quality standards to ensure the success of the digitization process and the proper preservation of manuscripts.

3.9 Manuscript Status and Reasons

Rejected:

- Quality less than 400 dpi (90 %) are insufficient to preserve fine details, making the manuscript unsuitable for digitization.
- Significant tilt in images makes them inconsistent and difficult to read (Figure 10).
- Blurred images lose important details, affecting readability and usability.
- Excessive glare in images hinders the clear visibility of text and illustrations, impeding the use of the manuscript.

Original Manuscript Review:

- Incorrect page sequence complicates the digitization process and makes the manuscript logically inconsistent.
- Missing pages reduce the manuscript’s research and historical value.

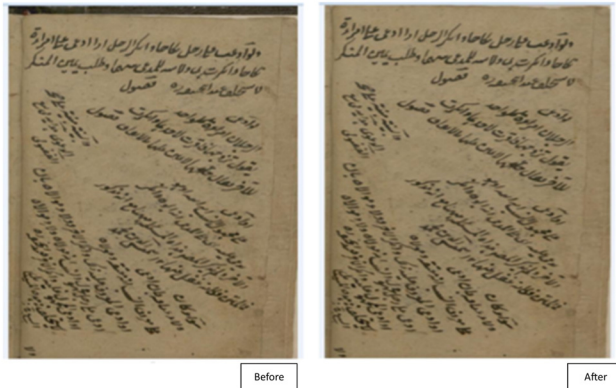


Figure 10: Improving the quality of digital images (significant tilt in the image).

- Incomplete margins on manuscript edges may contain important notes or comments, making the manuscript incomplete.
- Missing cover at the beginning or end: The manuscript cover is important for preserving the content and proper documentation.

4 Study Results

All manuscripts and rare books in good and medium condition were digitized according to their specific care procedures. Manuscripts in poor condition had their digital scanning postponed until they could be treated and restored to prevent further deterioration. A total of 13,411 manuscripts were digitized, while 2,280 manuscripts still need conservation treatment. The total number of digitized rare books reached 7,644. Additionally, 59 3D-artifacts were photographed using professional 3D and 2D imaging techniques. The manuscripts, rare books, and 3D-artifacts were digitized with high quality, reaching up to 600 dpi in various sizes and dimensions.

The digitization project adhered to internationally recognized standards to ensure high-quality, organized processes, and the preservation of manuscripts and rare books. It followed ISO guidelines, including ISO 19264-1 for image quality and resolution, and the Federal Agencies Digital Guidelines Initiative (FADGI) for metadata creation, file formats, and quality control. Additionally, best practices from the International Federation of Library Associations and Institutions (IFLA) were incorporated to manage and preserve digital collections effectively. This adherence safeguards the integrity of the materials and facilitates their accessibility for future use.

Various digitization techniques in the project provided diverse levels of detail and reliability. Among the most prominent techniques are high-resolution scanners that capture digital images at 600 dpi or higher, ensuring detailed and high-quality images. Advanced digital cameras help photograph manuscripts and rare books with high accuracy, adjusting lighting and contrast appropriately to avoid shadows and reflections. Additionally, image editing software is used to enhance digital image quality by correcting colors, removing distortions, and adjusting contrast, maintaining the visual authenticity of the manuscripts. Optical Character Recognition (OCR) software converts text in digital images into editable and searchable text, facilitating access to content and text analysis. Format conversion software enables converting digital files into various formats suitable for diverse user needs, ensuring compatibility with different platforms and devices. 3D imaging technology provides detailed views of artifacts, allowing users to view them from all angles and interact with them more realistically. These combined technologies offer a level of detail not achievable with traditional methods, contributing to the preservation and sustainability of cultural heritage for future generations.

The digital transformation system (DTS) offers numerous benefits that improve digitization processes and ensure their accuracy and efficiency. Firstly, the system ensures precise tracking of each transfer and digitization process, reducing errors and enhancing efficiency at all stages. Continuous tracking allows monitoring the location and status of each manuscript throughout the process, enhancing security and reliability. The system features automatic verification, helping to check the consistency of recorded data with actual manuscripts, ensuring the accuracy of stored information. In case of data mismatches, supervisors are immediately informed to take corrective actions, enhancing crisis management effectiveness. Additionally, DTS provides a secure environment for storing and archiving digital data, ensuring data preservation and easy access when needed, contributing to protecting valuable information and ensuring its sustainability for future use.

Quality control in the digitization project ensures converting manuscripts into high-quality digital copies retaining the finest details. It involves automatic checking of all images against set standards for digital image quality by saving and comparing images to the original manuscripts. All digital files are tested within a specific timeframe according to standardized scientific criteria.

Table 4 presents statistics showing significant user interaction with various collections from the digital repository system. The manuscripts collection recorded the highest engagement, with 223,273 views, followed by rare books with 76,843 views. Qur'an manuscripts received 8,773 views, while precious 3D-artifacts accumulated 965 views.

These results show that digitization has significantly enhanced researchers' and the public's ability to access and benefit from manuscripts. The high level of

Table 4: Number of views for collections extracted from the digital repository system. Date: 16/12/2023.

Collection	Number of views
Qur'an manuscripts	8,773
Manuscripts	223,273
Rare books	76,843
Precious 3D-artifacts	965
Total	309,854

Source: Digital Repository of King Abdulaziz Complex for Endowment Libraries.

engagement highlights the growing reach of these important cultural assets, reflecting real-world interaction and their increasing impact. Researchers could access digital copies from anywhere in the world through the Complex’s digital repository. The repository provides high-quality copies of parts of manuscripts, rare books, and 3D-artifacts, facilitating researchers’ search in the Complex’s collections using preservation numbers, titles, subjects, and authors. Currently, parts of manuscripts (beginning, middle, and end) are displayed, and researchers can request full images of manuscripts through the Complex’s digital portal, with the ability to zoom in and out on pages to show all fine details (King Abdulaziz Complex for Endowment Libraries 2023).

5 Recommendations

Based on these findings, the study recommends the adoption of digitization technologies and international standards in all cultural heritage preservation projects to ensure their sustainability and long-term accessibility. Digitization technologies enrich and enhance the digital cultural heritage by continuing digitization projects in libraries to effectively serve their users and preserve knowledge for future generations. Ethical considerations are crucial in the digitization of rare manuscripts. Information institutions should engage with cultural communities and ensure that digitization practices respect the cultural significance of materials and provide equitable access to digital resources. It is recommended to organize awareness campaigns for the community and researchers about the importance of digitization in preserving cultural and historical heritage and to provide workshops and training programs for employees in museums, libraries, and archives to increase awareness of the importance of digitization and best practices in this field. Furthermore, those responsible should encourage cooperation between academic institutions and research centers at both local and international levels to exchange knowledge and

experiences in digitization and develop joint research networks that contribute to the exchange of information and digital resources. Furthermore, periodic evaluations of digitization processes and policies should be conducted to ensure the achievement of desired goals. Finally, the quality benefits from review and improved practices based on evaluation results and feedback from users and researchers.

6 Conclusions

The digitization project of manuscripts at the King Abdulaziz Complex for Endowment Libraries is an important step towards preserving the cultural and historical heritage of Saudi Arabia and a central part of Saudi Vision 2030, which aims to enhance knowledge and culture by adopting the latest technologies. The project was implemented by trained and qualified Saudi hands, enhancing the national capacity to preserve cultural and historical heritage. This project has contributed to presenting cultural heritage in innovative and sustainable ways.

This approach not only strengthens national capacity but also contributes to the wider discourse of ethical archival practices, advocating for self-representation and the ability of nations to curate their histories on their own terms. By training and employing Saudi professionals, the country is not only safeguarding its past but also investing in the sustainable development of archival skills for future generations.

The process of digitizing manuscripts at the King Abdulaziz Complex for Endowment Libraries is a significant step towards preserving the cultural and historical heritage of Saudi Arabia. Ancient manuscripts and rare books are a valuable part of human cultural heritage, containing important historical, scientific, and literary knowledge. The digitization project at the King Abdulaziz Complex for Endowment Libraries represents a pioneering model in this context, combining rich cultural heritage with advanced technology to preserve the Kingdom's cultural treasures.

Applying global standards and practices in digitization processes ensures precise and organized documentation, enhancing research capabilities. This project makes the Kingdom's cultural heritage more widely available and reinforces the role of libraries as modern knowledge centers that keep pace with technological advancements. Through these efforts, the King Abdulaziz Complex for Endowment Libraries contributes to achieving the goals of Saudi Vision 2030, which aims to build an advanced knowledge society and preserve cultural heritage for future generations.

7 Limitations of the Study

This study offers valuable insights into the digitization efforts at the King Abdulaziz Complex for Endowment Libraries, but several limitations should be acknowledged. The research is based on observations and field visits to a single institution, limiting its applicability to other projects that may operate under different conditions and resources. Additionally, although the study highlights that 2,280 manuscripts remain undigitized due to the need for conservation treatment, it does not delve into the specific challenges or timelines associated with completing these efforts, which could affect future progress. The study also recognizes the use of advanced technology but does not address the difficulties of applying Optical Character Recognition (OCR) to Arabic manuscripts, which impacts the searchability and usability of the digital archive. Furthermore, the rapid evolution of technology presents another challenge, as the tools and methods used may quickly become outdated, requiring continuous adaptation. While the research emphasizes the importance of digital preservation, it lacks discussion on long-term risks, such as data corruption and cybersecurity threats, which are essential for ensuring the sustainability of digital archives. Acknowledging these limitations offers a roadmap for future research and practical improvements, helping ensure that digitization efforts continue to preserve, secure, and make cultural heritage accessible for future generations.

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Notes on the Author: The researcher is the general supervisor of the manuscript digitization and cataloging project at the King Abdulaziz Complex for Endowment Libraries.

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