ISSN: 3049-2971

chiefeditor@meadowpublication.com

Morphos

A Multidisciplinary Journal

Volume 3 No. 2 Nov-2025

MEADOW PUBLICATION

Morphos
A Multidisciplinary Journal

Volume.03 No.2 November-2025

Editor

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ISSN:	**3049-2971**
Starting Year:	**2025**
Frequency:	**03 times a year**
Format of Publication:	**Print**
Subject:	**Multidisciplinary Subjects**
Language:	**Multiple Languages (English, Hindi, Gujarati)**
Published by:	**Meadow Publication** 6 Prabhu Plaza, Opp. New Jilla Panchayat Himmatnagar, Gujarat 383001 **Phone:** +91 7861926733 **Email:** chiefeditor@meadowpublication.com

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Morphos A Multidisciplinary Journal is published 03 times a year in March, July, and November.

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- For the March issue: January 31st
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Morphos A Multidisciplinary Journal **ISSN(Print): 3049-2971**

Volume. 03 No. 2 November-2025
Open Access, Peer-Reviewed, Referred Journal

COMPARATIVE AUDIT STANDARDS: ISLAMIC AUDITING AND CONVENTIONAL AUDIT PRACTICES

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Abstract

This paper presents a comparative analysis of Islamic and conventional approaches to auditing fraud, highlighting their shared emphasis on governance stability, internal controls, and ethical conduct within financial institutions. Drawing on major corporate failures such as Enron, Lexus Granito India Ltd., and the Dubai Islamic Bank (DIB) debacle, the study demonstrates that departures from established auditing norms, whether under International Standards on Auditing or Shari'ah-compliant frameworks, generate significant legal, financial, and reputational risks. The findings further reveal that Islamic auditing entails additional layers of complexity, as auditors must ensure both financial accuracy and strict Shari'ah compliance. Governance breakdowns in DIB and related institutions underscore limitations in the competency of Shari'ah Supervisory Boards, misaligned managerial objectives, and inadequacies in audit mechanisms. The analysis suggests that the presence of well-trained and independent Shari'ah auditors, robust internal and external audit processes, and enhanced regulatory oversight are essential to mitigating such failures. Overall, the paper argues that auditing—whether Islamic or conventional—constitutes a fundamental pillar of trust, accountability, and ethical discipline. Strengthening professional skepticism, transparency, and technological compliance systems can enable financial institutions to reinforce governance structures, reduce exposure to ethical lapses, and safeguard stakeholder interests.

Introduction

"Audit is the flashlight in the dark corners of financial reporting." – James Chanos

Auditing is the foundation of trust and transparency in financial reporting. Without it, stakeholders have no guarantee that what an organization states in its accounting is what has truly been done. In the best words of the Institute of Chartered Accountants of India, auditing is "*an independent examination of the financial statements of any enterprise, whether it is profit-oriented or not, regardless of the size or the legal form, and when such an examination is conducted with a view to expressing an opinion thereon*." The chief aims of auditing include,

not limited to the following, checking the proper distinction of capital and revenue nature of transactions; confirming the existence and value of assets and liabilities; verifying whether all the statutory requirements are fulfilled or not; proving true and fairness of operating results presented by income statement and financial position presented by balance sheet.

While regular audits focus mainly on adherence to accounting standards and risk management, Islamic auditing adds extra layers of ethical and Shari'ah compliance. Not only do Islamic audits check financial accuracy, but they also ensure that Islamic transactions and operations follow Islamic law.

This paper explores the auditing practices of conventional and Islamic financial institutions. It compares the two systems and includes notable examples. This paper highlights the failures in auditing and governance, outlines the role of international and national standards such as ISAs, SAs, and AAOIFI guidelines, and examines how Islamic auditing approaches can benefit from traditional methods. The research makes an attempt to include the mistakes of the auditing cases, along with regulatory weaknesses and current best practice, thereby providing valuable auditing insights that could potentially enhance the present condition of compliance, transparency, and ethical oversight in both conventional and Islamic financial sectors.

Objectives, Methodology and Scope

Objectives

- To understand and examine the structural frameworks of both Islamic and conventional auditing in the financial sector.
- To outline ways that may improve the standards of Islamic auditing and integration with conventional auditing practices.

Methodology

Research Design: This paper adopts a qualitative, comparative research design, analyzing multiple case studies to draw lessons for auditing practices.

Data Collection: Secondary data is collected from scholarly articles, regulatory reports, auditing standards, official case documents, news reports, and institutional disclosures. Key sources include ICAI publications, AAOIFI guidelines, IAASB pronouncements, and academic journals.

Analysis Approach: Each case study is analyzed under three dimensions: (i) factual background, (ii) auditing and governance failures, and (iii) resulting implications. Conventional auditing failures are compared with Islamic auditing lapses to identify similarities, differences, and potential areas for cross-learning.

Comparative Framework: The research evaluates how ISAs and SAs could have prevented the failures in both conventional and Islamic contexts, highlighting specific standards violated and lessons for institutional governance.

Scope

This article presents a comparison between auditing procedures in Conventional and Islamic financial institutions. It refers to the following examples: Enron, Dubai Islamic Bank, Islamic Bank Ltd. of South Africa, and Lexus Granito India Ltd. This examination is looking for real ways to better auditing practices, to enhance Shari'ah governance, and to make it easier for financial institutions to be open and accountable.

Review of Literature

Yusoff[1] and colleagues (2024) investigate how internal Shariah audit can be a source disclosing non-Shariah-compliant activities. Through the use of case research and interviews, they find that internal audits are normally able to uncover regular compliance-related issues, but they may encounter problems with complex financial products. The authors put forward the idea that more auditor preparation and a closer coordination between Shariah audit activities and standard risk-based audit approaches should be the method for complete oversight.

El-Halaby (2021)[2] depicts the systematic review of studies related to the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) standards. This paper traces how the Islamic finance reporting has developed and indicates that despite AAOIFI's having released detailed directives for Shariah governance and auditing, the implementation of these standards is still different in various jurisdictions. The differences in the degree of adoption lead to various Shariah compliance interpretations, and hence it becomes challenging to carry out cross-border assurance. The review stresses that although AAOIFI has elevated the standard of Islamic auditing practice, a lot of the changes with the international auditing norms are still required.

Ayu et al. (2024)[3] examine how effectively Sharia audits function as a mechanism to safeguard compliance in Islamic financial institutions. Based on a mixed-methods design, the authors of this paper combine data from interviews with Shariah auditors and analysis of institutional

[1] Yusri Hazrol Yusoff and others, 'Role of Internal Shariah Audit to Detect Non-Shariah Compliance' (2024) VIII International Journal of Research and Innovation in Social Science 2947.
[2] Sherif El-Halaby, Sameh Aboul-Dahab and Nuha Bin Qoud, 'A Systematic Literature Review on AAOIFI Standards' (2021) 19 Journal of Financial Reporting and Accounting 133 <https://www.sciencedirect.com/org/science/article/abs/pii/S1985251721000258?utm_source=chatgpt.com> accessed 18 September 2025.
[3] Sandra Ayu Ayu, Maisya Pratiwi and Wemi Aryuna, 'The Effectiveness of Sharia Audit in Islamic Financial Institution' (2024) 8 EKONOMIKA SYARIAH : Journal of Economic Studies 219.

reports, to demonstrate that the effectiveness of Sharia audits largely depends upon the competence of Shariah auditors, the clarity of Shariah standards, and the support of senior management. The document points out that though Shariah audits are instrumental in stakeholder confidence and in decreasing the chances of non-compliant financial products, there are still some auditor independence and standardised audit procedure issues that exist in different jurisdictions. The outcome herein reflects that, when put side by side with conventional audits regulated under the well-established International Standards on Auditing (ISA), Shariah audits still call for more professionalisation and codification to become of the same quality level.

The paper "Issues and Challenges of Auditing in Islamic Financial Institutions" by Mathew Kevin Bosi and Melissa Della[4] Joy highlights the rapid global expansion of Islamic Finance Institutions and the consequent demand for Shari'ah-compliant audits. It reflects that traditional auditing standards are neutral and cannot fully meet the Islamic ethical and legal requirements. Among the main issues are lack of complete Shari'ah auditing standards, the risk of auditor independence as Shari'ah Supervisory Boards are paid by the institutions, shortage of auditors qualified in both Shari'ah and conventional auditing, and limited accountability of Shari'ah auditors in decision-making. The writers are advocating for a robust regulatory framework, more independence, and a higher number of dual-qualified auditors to guarantee authentic Shari'ah audits.

A recent study on Islamic Financial Institutions (IFIs) in the UAE examines how the independence of the Shariah Supervisory Board (SSB) influences the effectiveness of internal Shariah audits[5]. Based on the survey of nearly 100 IFI professionals, the study concluded that there is a definite positive link between the degree of independence of the SSB and the capabilities of the internal Shariah auditors in achieving compliance with Islamic financial principles. The authors state that when the SSB is seen as independent in both the organization and decision-making, the internal audit function goes on to have more credibility and assurance, hence, the stakeholder's trust in SSB compliance is further strengthened.

[4] Mathew Kevin Bosi and Melissa Della Joy, 'Issues and Challenges of Auditing In Islamic Financial Institutions' (2017) 6 International Journal of Humanities and Social Science Invention 15 <www.ijhssi.org>.
[5] Hussein Alwan Dhahir Alani, Azam Abdelhakeem Khalid and Ahmad Zakirullah Mohamed, ' The Impact of SSB Independence on the Effectiveness of Internal Shariah Auditor among IFIs in UAE' (2023) 16 International Business Education Journal <https://ejournal.upsi.edu.my/index.php/IBEJ/article/view/7720/4499> accessed 19 September 2025.

Framework of Islamic Auditing

Islamic auditing serves the purpose of providing double confirmation: it first of all confirms the truthfulness of the financial statements, and next it certifies that the institution's activities are in line with the principles of Shariʿah law. The Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI)[6], which was established in Bahrain in 1991, is the foremost international standard-setter in this area. Besides, it makes, issues, and interprets the standards that are a combination of the conventional auditing discipline and the requirements of Islamic jurisprudence, thus leading to the increased trust of the Islamic Financial Institutions (IFIs) financial reporting. Quite a considerable number of central banks and supervisory authorities either recognise or adopt these standards which confer them quasi-regulatory force in different countries.

One of the major objectives that the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) lists is the development of accounting and auditing concepts and practices that are applicable to the Islamic financial institutions. Secondly, it is in their mission to spread the concepts and practices they have developed through educational training, conferences, the publication of periodicals, and activities such as research, and similar contributions. Besides these aims, the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) is empowered to produce, promote and explain the accounting and auditing standards that specifically target the Islamic financial institutions. The last, but not the least, it undertakes to constantly review and revise these regulations so as to make sure that they continue being relevant and up to the mark.

The Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) launched the standards of auditing (SAIs) specifically for Islamic financial institutions. The new standards deliver the Shari'ah principles in the audit process, going deeper than just the traditional auditing practices. The first stage in the development of the standards has defined four bases: (1) Objectives and Principles of Auditing; (2) The Auditor's Report; (3) Terms of Audit Engagement; and (4) Testing for Compliance with Shari'ah Rules and Principles. The latter not only indicates the closeness of the auditors' work to the users of financial statements as one of the requirements of professionalism, but also as a religious requirement to be in line with the Islamic law.

The first standard, Objectives and Principles of Auditing, describes the core elements of the process of auditing the Islamic financial institutions. This part has fourteen paragraphs and the main point it makes is that the goal of the audit should not be the mere observance of accounting

[6] AAOIFI, *Shariʿah Standards* (2015) Introduction 21.

standards only. Accordingly, the auditors are required to affirm whether the financial statements reflect the Shari'ah, AAOIFI accounting standards, and local practices and regulations. To be sure, in this respect, the auditor is charged with not only the responsibility of a professional but also that of a religious one and thus, by implication, the auditor becomes the witness of Islamic finance producing the cleanest transaction that are devoid of prohibited elements like riba (interest) and excessive uncertainty. This double obligation is what is at the core of the AAOIFI auditing standards vis-a-vis others like the International Standards on Auditing (ISA).

Auditor's Report[7], the second standard, is the most detailed and wide-ranging, with forty-seven paragraphs. The standard outlines very detailed requirements about the format, content, and coverage of the auditor's report. The auditor apart from the typical role of identifying a truthful picture of the financial statements is also required to decide on their Shari'ah compliance as per the interpretation of the institution's Shari'ah Supervisory Board (SSB). The standard is focused on the point of collecting enough and appropriate audit evidence before the auditor reaches his/her conclusion. Basically, the standard is the one that guarantees the auditor's report to be a fair and straightforward opinion on the institution's performance along with an indication of its religious obligations.

Terms of Audit Engagement[8], the third standard, outlines the contractual and professional relations between the client institution and the auditor. The third standard consists of the 29 paragraphs, which say that the terms of engagement must be both orally agreed upon and properly written down, usually, in the form of an engagement letter. By doing that, the range of the audit, the duties of the auditor and the client, and the nature of the assurance to be given are all clearly defined. Besides, the standard also demarcates between the statutory audits that are mandated by law and a review of Shari'ah compliance is needed, and professional services such as tax or consultancy, which do not imply the same level of assurance. The main reason behind this standard is to lessen the number of misunderstanding under the condition of existence of the auditor's independence and client's expectations by formalizing the terms of engagement.

Once on the other hand, the last and fourth standard is Testing for Compliance[9] with Shari'ah Rules and Principles by an External Auditor. This standard, consisting of eighteen paragraphs, is the most distinctive feature of Islamic auditing, which is the need of Shari'ah compliance checking. The external auditors ought to ascertain and effectuating the audit procedures that allow them to take "reasonable assurance" that the organization's financial activities are in accordance with the Islamic principles in the Shari'ah. In the meantime, they are not supposed

[7] ibid.
[8] ibid. p. 40.
[9] ibid.

to take the SSB's decision for granted and must do their own research to confirm that the contracts or products used in the transaction are in accordance with Shari'ah. It is the auditor's part to be the one who certifies the religious credibility of Islamic finance and not only that, but compliance is rigorously tested and assured**.**

Those four standards, taken together, constitute the features of auditing in the Islamic finance sector that are so different from the rest. They do not only pledge to international auditing principles such as evidencing and professional independence but also incorporate the moral and religious obligations of Shari'ah. By so doing, they assure the confidence of both regulators and stakeholders thus, Islamic financial institutions are allowed to practice with full compliance to their founding principles.

In addition to these standards, a robust Islamic auditing framework incorporates complementary elements to strengthen compliance and governance. A well-structured Shari'ah governance system, led by the Shari'ah Supervisory Board (SSB) and supported by an Audit and Governance Committee, provides oversight and ensures that audit findings are addressed effectively[10]. A risk-based approach allows auditors to identify, assess, and mitigate Shari'ah-specific risks, focusing resources on areas most susceptible to non-compliance[11]. Comprehensive internal control assessment integrates Shari'ah compliance checks with standard financial controls, ensuring transactions are properly authorized, recorded, and reconciled[12]. Finally, adherence to ethical and professional standards, including independence, confidentiality, due professional care, and auditor competence, reinforces the credibility and reliability of both financial and Shari'ah audits[13].

Collectively, these four auditing standards and supporting framework elements create a comprehensive system for auditing Islamic financial institutions, ensuring accuracy, Shari'ah compliance, ethical integrity, and stakeholder confidence[14].

Framework of Conventional Auditing

The International Standards on Auditing (ISAs) are a globally recognized set of professional standards issued by the International Auditing and Assurance Standards Board under the International Federation of Accountants. They provide a clear framework for conducting high-quality audits of financial statements, ensuring consistency and credibility in the assurance provided to stakeholders across various countries and industries. The main goals of ISAs are

[10] 'Framework of Auditing' <https://aaoifi.com/exposure-drafts-3/?lang=en>.
[11] Suleiman Dalhatu Sani and Mustapha Abubakar, 'A Proposed Framework for Implementing Risk-Based Shari'ah Audit' (2020) 19 Journal of Financial Reporting and Accounting 349.
[12] Latifah Algabry and others, 'Conceptual Framework of Internal Sharīʿah Audit Effectiveness Factors in Islamic Banks' (2020) 12 ISRA International Journal of Islamic Finance 171.
[13] 'Framework of Auditing' (n 11).
[14] Algabry and others (n 13).

to improve the reliability and transparency of financial reporting by guiding auditors in planning and performing audits. They help evaluate the risks of a material misstatement, evidence the sufficiency and appropriateness of the same, and form a completely separate view on whether the financial statements disclose that they comply with the relevant financial reporting standards and are true and fair. By defining the common ground of auditor care requirements, for example, professional skepticism, moral behavior, and evidence-based reporting, ISAs give room for public trust in the honesty of financial data and foster the worldwide comparability of the audit practice.

Traditional auditing is primarily regulated by the International Standards on Auditing (ISAs) set by the International Auditing and Assurance Standards Board (IAASB) under the International Federation of Accountants (IFAC). The standards offer a framework that is globally recognizable for performing the financial statement audits and has as its goal the establishment of the same audit behavior and reliability across all the different legal systems. The ISAs are arranged in order of logic. ISAs 200–299 describe the general principles and the auditor's main responsibilities. They include objectives, ethical requirements, and the necessity of proper planning. ISAs 300–499[15] deal with risk assessment and responses. They require auditors to understand the entity's business, identify and assess risks of material misstatement, and design suitable audit procedures. ISAs 500–599[16] focus on audit evidence and offer detailed guidance on how to obtain enough appropriate evidence, including standards on sampling and external confirmations. ISAs 600–699[17] address using the work of others, such as group audits and reliance on experts or internal auditors. ISAs 700–799[18] guide auditors in drawing conclusions and reporting, including how to draft and modify the auditor's opinion. Finally, ISAs 800–899[19] cover specialized areas like audits of special purpose financial statements and compliance engagements.

The framework of conventional auditing rests on a set of basic principles. Auditors must maintain integrity, objectivity, and independence, ensuring their professional judgment remains free from bias or conflicts of interest. They ought to show professional skill and care by maintaining their knowledge and updating their skills as well as using them effectively. Keeping information private is also a fundamental duty; auditors should safeguard the client information that has been accessed in the audit process. Most importantly, the auditor's opinion

[15] ibid.
[16] 'INTERNATIONAL STANDARD ON AUDITING 500 Concept of Audit Evidence' [2004] Instituto de Censores Jurados de Cuentas de España 424.
[17] International Auditing and Assurance Standards Board (n 16).
[18] ibid.
[19] 'ISA 800 (Revised), Special Considerations─Audits of Financial Statements Prepared in Accordance with Special Purpose Frameworks | IAASB' <https://www.iaasb.org/publications/isa-800-revised-special-considerations-audits-financial-statements-prepared-accordance-special> accessed 20 September 2025.

has to originate from the use of adequate and appropriate evidence and give a level of reasonable assurance. This refers to giving quite a high, though not absolute, level of trust that the financial statements do not contain any significant errors or frauds.

Along with the international framework, there are also the national standards which apply in a lot of countries.In India, for example, the Institute of Chartered Accountants of India (ICAI) has issued Standards on Auditing (SAs) closely aligned with the ISAs. Key SAs include SA 200[20] on the overall objectives of the independent auditor and the conduct of an audit, SA 230[21] on audit documentation, SA 315[22] on identifying and assessing the risks of material misstatement, SA 330[23] on the auditor's responses to assessed risks, SA 500[24] on audit evidence, and SA 700[25] on forming an opinion and reporting on financial statements. These SAs ensure that audits meet both international benchmarks and local statutory requirements, such as those set out in Section 143[26] of the Companies Act, 2013.

Together, these standards create a risk-based and evidence-driven framework for conventional auditing. The auditor begins by planning and designing the audit based on a thorough understanding of the entity and its environment and by assessing the risks of material misstatement. They then implement audit procedures to obtain enough appropriate evidence, which is carefully evaluated to draw conclusions. Finally, the auditor provides an opinion through a formal auditor's report stating whether the financial statements present a true and fair view of the entity's financial position and performance. This structured approach supports public trust in financial reporting and enhances the accountability and transparency of organizations.

Recommendations

[20] '200 (REVISED) OVERALL OBJECTIVES OF THE INDEPENDENT AUDITOR AND THE CONDUCT OF AN AUDIT IN ACCORDANCE WITH STANDARDS ON AUDITING' [2020] The Institute of Chartered Accountants of India.
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[23] ibid.
[24] 'SA 500 AUDIT EVIDENCE' The Institute of Chartered Accountants of India <https://www.icai.org/post/6191>.
[25] 'SA 700 FORMING AN OPINION AND REPORTING ON FINANCIAL STATEMENTS' The Institute of Chartered Accountants of India <https://www.icai.org/post/6191>.

[26] Companies Act 2013 (18 of 2013) s 143.

The repeated failures in the governance of Islamic financial institutions caused by factors like weak Shari'ah boards, and the gaps between regulations highlight an urgent need to improve auditing in Islamic finance not simply for compliance but also for assurance of ethical integrity. It is extremely critical for all internally and externally mandated independent auditors with expertise in both Islamic jurisprudence and modern finance to have robust internal and mandatory external Shari'ah audits. In order to confirm that the principles of Shari'ah have been strictly abided by, these audits must not only go through the documents but should also include transaction testing and detailed verification of investment activity.

Independence of auditors is the factor that is of most importance. The cases where the same individual has held more than one position, service or financial benefit agreements, which have affected the fairness of the work, should be banned so that the auditors may report any non-compliance cases without any worries of retaliation.

Transparency and reporting are also crucial elements in the matter that can be further improved. Standardized reporting frameworks should aim to make it easier and clearer for the audit findings to be communicated to the whole range of the interested audience including investors, depositors, and regulators who should be able to tell from the reports whether there has been true Shari'ah compliance. Simultaneously, the performance of the auditor, that hinges on his/her resources, and these should be developed through professionally conducted training courses which will be the dual expertise of Islamic law and conventional finance and which will enable the auditor to properly assess the complexity of Islamic financial instruments and at the same time, identify the smallest Shari'ah issues in the product.

The role of the regulator, however, is just supporting the job of the auditor by giving the professional standard at the very minimum that the auditors should pass and then by judging their visit, whether it is scheduled or unexpected, and if they have found neglect or misconduct, they are able to impose the adequate penalty following the defined sanctions. Lastly, providing various means for the participation of the stakeholders, particularly through education and disclosure, invites simple and easy access to information and then the making of a well-informed decision, which, in turn, will promote good ethical practices as well as enforce long-term trust in Islamic financial institutions.

Conclusion

A comparative analysis of the Islamic and conventional fraud in auditing is quite insightful. Both of them emphasize the need for stability in the field of governance, execution of controls and keeping up ethical standards in financial institutions. The incidents such as Enron, Lexus Granito India Ltd. crisis, and Dubai Islamic Bank debacle, point out as well that the divergence from the auditing standards leads to the creation of a whole range of problems resulting in

severe financial, legal, and reputational consequences, regardless if it is under the International Standards on Auditing or Shari'ah-compliant frameworks.

For instance, the case of DIB and the other Islamic financial institutions, the Islamic auditing system, is more challenging as it has to be not only financially accurate but strictly Shari'ah compliant as well. The lack of competency in the Shari'ah Supervisory Board, the management's divergence in objectives, and the inadequacy of auditing mechanisms have been the major causes of the governance failures. The raised issues clearly indicate that the necessity of a well-trained, independent Shari'ah auditor, the strict internal and external audit process, and the enhanced supervisory role by the regulator cannot be underestimated.

The foremost teachings from the examples given here are that auditing needs to be depicted not only as a technical task but also as one of the fundamental pillars of trust, accountability, and the ethical behavior. Indeed, an effective audit, whether conventional or Islamic, will require the incorporation and adherence to professional skepticism, transparency, independence, and continuous learning that is aligned with the introduction of new financial instruments. By looking into the past errors, the conventional as well as the Islamic financial institutions are better able to improve their governance frameworks, so as to reduce their exposure to the risk of ethical lapses and, also, protect the interests of the stakeholders. The future financial prosperity that is rooted in credibility, accountability, and sustainable ethical practices can be safeguarded through a combination of the auditing standards, the professional training, and the compliance system driven by technology.

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Morphos A Multidisciplinary Journal **ISSN(Print): 3049-2971**

Volume. 03 No. 2 November-2025
Open Access, Peer-Reviewed, Referred Journal

Bridging Traditions with Technology: Reviving Manuscripts to Metadata by Harnessing AI in Humanities, Culture and Media

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Abstract

India's culture extents thousands of years and integrate a wide collection of manuscripts, monuments and intangible traditions. However, much of all these remains dispersed, fragmented, or at risk to physical deterioration. Recent technological advancements in Artificial Intelligence (AI) have begun to fundamentally shift how this immense legacy is well preserved, studied, researched, and shared in humanities, cultural studies and media. The research paper, "Bridging Traditions with Technology: Reviving Manuscripts to Metadata by Harnessing AI in Humanities, Culture and Media", examines the application if AI technologies, including handwriting recognition and machine learning to digitize and restore India's extensive cultural heritage.

The research paper "Bridging Traditions with Technology: Reviving Manuscripts to Metadata by Harnessing AI in Humanities, Culture and Media" is divided into two significant parts, viz. the illustrations and examples of India's rich culture in various fields of subjects and subsequently highlights how AI converts written and scattered manuscripts in to searchable digital resources with rich metadata for easier access to the researchers, academicians and public in general.

Keywords: *AI in Humanities, Culture and Media*

Introduction

The preservation, study and research of ancient manuscripts have been very important to understanding human history and culture. It helps to transfer the gained knowledge across generations. These manuscripts serve as tangible evidences from past civilizations; languages, philosophies, and artistic expressions, making our cultural heritage rich with invaluable

treasures that ignite pride in our shared cultural legacy. However, these manuscripts face severe risks from natural decay, and historical neglect. Traditional methods of preservation depend heavily upon physical maintenance and manual transcriptions. The challenge of preservation and access is compounded by linguistic diversity, complex script forms, and sheer physical volume of records distributed across public and private collections. Against this backdrop, artificial intelligence (AI) is emerging as a transformative device to bridge the gap between traditions and technological abilities by transforming manuscripts preservation into metadata for an easy access to various research domains including humanities, culture and media.

"*Artificial Intelligence can analyse historical texts to understand the historical and social contexts of the period in which we are writing*." (Alalaq, 2025). Artificial Intelligence (AI) technologies such as Optical Character Recognition (OCR), Handwriting Text Recognition (HTR), Natural Language Processing (NLP), and machine learning have unlocked new potentials for digitizing, transcribing, and analysing manuscripts that were previously unreachable or too damaged for traditional research methods. These AI integrated technologies do not merely reproduce physical copies in digital forms but enhance manuscripts into richly interpreted digital articles instilled with searchable metadata, related cross-referencing, and collaborative competences. Through AI powered data processing, historical texts can be restored, translated, decoded, and reinterpreted with exceptional accuracy, enabling scholars and the public to explore cultural heritage in more vibrant and comprehensive way.

> "*India is estimated to possess ten million manuscripts on varied subjects such as Ayurveda, astronomy, mathematics, linguistics, architecture and philosophy. Each manuscript is a living testament to the Bharatiya Gyan Parampara, the unbroken flow of indigenous knowledge that has nurtured Indian civilisation for millennia*." (Kumar, Vivek: 2025).

The benefits of applying AI extend beyond digitization and preservation, impelling present-day humanities and media scholarship. By converting manuscripts to organized metadata, AI facilitates refined data mining, comparative textual analysis, and interdisciplinary research methodologies. Through metadata generation and language translation tools, AI also supports the global distribution of knowledge traditionally limited to specific geographical or linguistic contexts. Moreover, AI tools allow for multimedia integration, linking texts with images, audio, and video to enrich cultural storytelling and public engagement. "*The use of AI in accessibility is not limited to language translation. AI technologies, including speech to text and adaptive user interfaces, can make media consumption more accessible for individuals with disabilities*." (Wah, J.N.K.: 2025). Such technological amplification transforms manuscripts

from static artefacts into dynamic and collaborative knowledge centres that resonate with modern digital learning and cultural consumption arrays.

India's Cultural Heritage through Manuscripts: Selected Illustrations

Cultural heritage of India through manuscripts denotes one of the richest and most diverse reservoirs of historical, literary, scientific, philosophical, and religious knowledge. Manuscripts are physical witnesses to the intellectual history of our country, recorded on various materials including palm leaves, birch bark, paper, cloth, and even metal sheets. "*A manuscript is a handwritten composition on paper, bark, cloth, metal, palm leaf or any other material dating back at least seventy-five years that has significant scientific, historical or aesthetic value*," (National Mission for Manuscripts). These manuscripts not only preserve ancient texts but also embody the artistry of calligraphy, illumination, and illustration reflective of regional traditions and languages.

Following are few selected illustrations of India's cultural and historical legacy across disciplines like Astronomy, Astrology, Psychology, Science, Mathematics, Medical, Arts, Architecture, Music, Textile, Language Grammar, etc.:
Astronomical Evidences in *Hanuman Chalisa:*

जुग सहस्त्र जोजन पर भानू ।
लील्यो ताहि मधुर फ़ल जानू ॥१८॥

This AI generated image of the Lord Hanuman holding the Sun on his hand is not only one the bravest act of his childhood but also symbolizes deeper meaning. Written by Tulsidas, *Hanuman Chalisa* is one of the famous scripts written, not only depicting the valour of the Lord Hanuman but also a hidden gem of science, astrology and neuropsychology. As per the mentioned verse above, one 'Yug' means Twelve Thousand Years; one 'Sahastra' is equals to 1000; and one 'Yojana' means 08 Miles. Multiplying all these will bring the estimated distance calculated by NASA to reach the Sun from the Earth i.e. 153,600,000 kilometres to the Sun. This reveals the advanced astronomical knowledge of the ancient India.

Science, Ayurveda and Math behind Chanting any Mantra 108 Times:

"*Chanting of 108 times indicates that this is the galactic ratio of the planet… as we divided the distance of Sun and earth by the diameter of Sun its value comes closer to 108. Similarly, when we divided the distance of earth to moon by the diameter of moon again its value comes closer to 108.*" (Anand, 2024: 13).

Chanting a mantra or any divinely name for 108 times is often linked to a 'cosmic' or 'galactic' ratio in traditional Indian astronomy as the number 108 approximates ratios involving the Sun, the Earth and the Moon (as shown in the above-mentioned AI generated image). The 108 beads in chanting mala are often associated with the multiplication of twelve zodiac signs or 'Rashi' with nine planets or 'Grah'. It became one of the spiritual symbols. Along with the spiritual significance, it holds bodily significance as well. According to *Sushruta Samhita*, the human body has 108 vital points, also called as '*Marma Bindu*' which is very crucial for life energy (*Paraná)*. These are sensitive points in the body where limbs, joints, muscles, veins and bones intersect, injury to which can lead to pain, deformity, ailments and sometimes, death. Thus, the Marma points are not just Ayurveda junction but are considered as sources of energies for mind, body and soul.

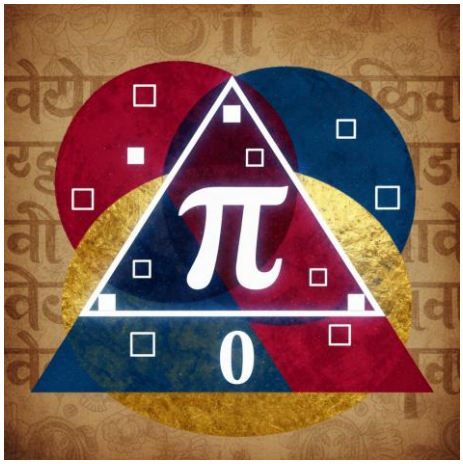
Is the Earth Spherical? *Varaha Avatar* of Lord Vishnu:

The image mentioned here is of Lord Vishnu in *Varaha Avatar*, holding the Goddess of Earth (Bhudevi) on his hand and the Spherical Earth lifting to its tusks symbolising the lift of the Earth from chaos after the killing of the demon named Hiranyaksha. It is situated at the Varaha Temple, Khajuraho, Madhya Pradesh. It is a monolith sandstone statue of Varahadev, half human and half boar. While scientists and researchers were debating whether the Earth is round or flat, India was already worshipping a deity that symbolized this truth. This sculpture, especially, depicts the Earth as a round globe being lifted by Lord Vishnu in his boar form, his third incarnation. This illustrates an early understanding of the

Earth's shape through religious art and symbolism. This sculpture reflects recognition of ancient Indian knowledge of the roundness of the Earth long before modern scientific discovered the same.

Aeronautical Science in Ancient Indian Scriptures:

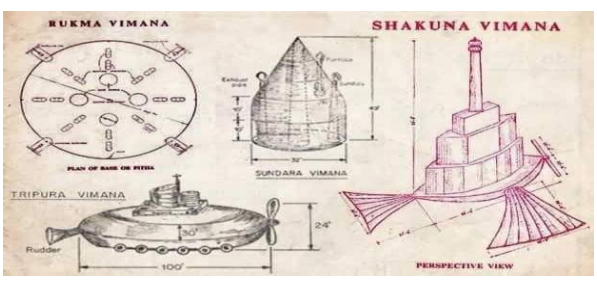
The shown image is retrieved (https://vastutantraastro.wordpress.com/wp-content/uploads/2020/12/fb_img_1607168952748.jpg?w=621) for the illustration purposes; depicting the types of aircrafts (Viman) mentioned in Indian aeronautical science. Sanskrit epics including the *Ramayana* and puranic literature mentions a term '*Vimana*', which refers to the flying palaces, chariots and divine vehicles used by the gods, heroes and other extraordinary beings.



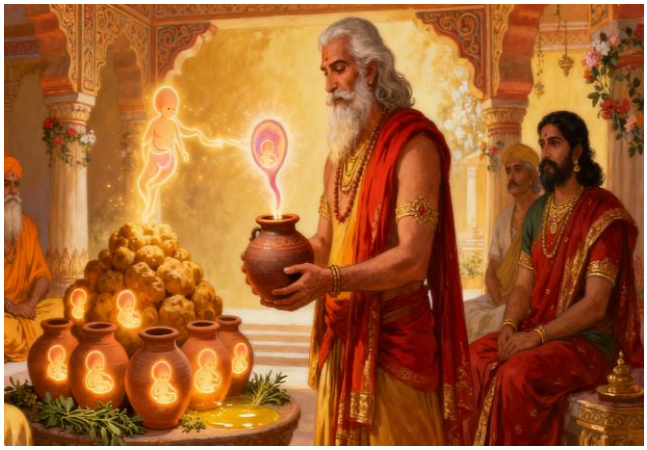
The most famous example of the aeronautical science or an aircraft is 'Pushpak Vimana' in the *Ramayana*. In 20th Century, a text named *Vimanika Shastra* revealed an ancient Indian aeronautical science including the designs of the aircrafts, propulsion system like mercury engines and flight manuals.

Advanced Mathematics in Indian Manuscripts:

This AI generated image is illustrating an artistic blend of mathematical discoveries of the ancient Indian Mathematics. The invention of Zero or 'Shunya' as a number is attributed to Aryabhata. Zero as a concept and number was invented in ancient India, with its earliest use traced to Indian mathematicians around the 3rd to 5th centuries CE. The Bakhshali manuscript, contains the earliest use of zero as a dot symbol serving as a placeholder. Brahmagupta, a 7th-century mathematician, was the first to define zero as a number with specific arithmetic rules, such as zero plus or minus a number and multiplication by zero. Along with 'Zero', Aryabhata had also provided the accurate approximation of the value of Pi, commonly used as 22/7 or 3.1416. Calculations regarding the value of Pi can also be traced from the Sulba Sutras, ancient Vedic texts. These texts were primarily concerned with constructing fire altars with precise shapes and sizes, thus necessitating knowledge of right triangles and their properties. The Pythagorean theorem, which states that in a right-angled triangle the square of the hypotenuse equals the sum of the squares of the other two sides, was known in ancient India long before Pythagoras. The Indian version of the theorem was part of practical geometry and construction techniques and was also described algebraically by later mathematicians like Baudhayana and



Apastamba in their Sulba Sutras. Thus, the Pythagorean theorem has deep roots in Indian Mathematics.



Ancient Assisted Reproduction from the *Mahabharata*:

The *Mahabharata* comprehends fascinating accounts that are going parallel with the modern concept of test tube babies or artificial birth. The AI illustrated image represents the birth of infants in pots, similarly to test tube babies. There are three instances in the *Mahabharata* which represent ancient assisted reproduction of the ancient India. For example, Guru Dronacharya, the teacher of the princes of King Dhritarashtra and King Pandu; is described as being born from a pot. The word 'Drona' means a pot, where Sage the reproductive fluid of Bharadwaja was preserved and nurtured outside a woman's womb, resembling in vitro fertilization (IVF) despite being framed mythological.

Another notable story is the birth of the 100 Kauravas. Gandhari gave birth to an unformed lump after an extended pregnancy, which Sage Vyasa divided into 101 parts and placed in clay pots filled with ghee and herbs, from which the Kauravas and their sister Duhshala were born. This process is comparable to tissue culture and multiple embryo development in artificial reproductive technology. Similarly, the birth of Lord Balarama, the elder brother of Lord Krishna, also involved embryo transfer, where his foetus was shifted from Devaki's womb to Rohini's womb to protect him, effectively making her a surrogate mother. These narratives from the *Mahabharata* highlight how ancient Indian epics seem to recognize assisted reproductive technology concepts, illustrating advanced ideas about reproduction long before they were scientifically formalized.

Language Grammar in Panini's *Aṣṭādhyāyī*:

> "*Panini's Aṣṭādhyāyī is a treatise in the vyakarana domain that contains 4000 sutras that provide an intricate system of rules that interpret a confounding array of linguistic matters, like the composition of nouns and case relations, the transformation of roots and nouns using suffixes, accent changes in word formation and sentence construction*." (Devi. A: 9).

The Vedas are among the earliest texts that laid the foundation for the study of language in ancient India. During the later Vedic period, Sanskrit emerged as a highly precise and expressive language, becoming a sophisticated tool for communication and literary expression.

This was a time when Sanskrit was refined and developed extensively, allowing ancient scholars to compose significant texts such as the Brahmans and Upanishads. These works further enriched the linguistic environment, offering detailed exploration of grammar and language structures. In the Axial Age (800 – 200 BCE), there was a major shift in Indian culture and philosophy. This period witnessed the rise of important philosophical schools including Vedanta, Samkhya, Nyaya, and Mimamsa. These developments provided a rich context for the study of language, grammar, and logic, shaping how linguistic inquiry evolved during this transformative phase.

Aṣṭādhyāyī is an ancient and highly systematic treatise on Sanskrit grammar. It consists of nearly 4,000 concise rules that define Sanskrit morphology, phonetics, and syntax with precision. Panini used a meta-language and a system of technical markers to create an algorithmic grammar that generates all correct forms of the language. Similarly, Chomsky's idea of Generative Grammar, models the innate human capacity to generate and understand an infinite number of sentences from a finite set of rules. It emphasizes the idea of a universal grammar underlying all human languages, describing syntactic structures through formal rules and transformations.

Reviving Manuscripts to Metadata by Harnessing AI

"*AI is not just a tool for preservation; it is a bridge that connects the whispers of the past to the digital agora of the present*," (Kumar, 2025). Historical manuscripts, repositories of ancient Indian knowledge in philosophy, medicine, psychology, linguistics, astronomy, science and arts face threats from deterioration, inaccessibility, and limited manual transcription. Artificial Intelligence (AI) transforms this challenge into opportunity by digitizing fragile documents through advanced optical character recognition (OCR), handwriting recognition, and deep neural networks, converting images into searchable, editable text and metadata. It also helps to decode symbols and codes on its level.

For example, recently, the Buga Sphere, a mysterious metallic object was discovered in Colombia in 2025. Advanced AI, including quantum AI and neural networks, has played a significant role in decrypting the complex structure, patterns, and symbols of the Buga Sphere. The sphere encloses intricately layered concentric metal shells, microspheres, fibre-optic-like wiring, and a central core signifying it might function as substantial information storage and processing device. AI analysis has revealed that the Buga Sphere responds to vibrations such as ancient Sanskrit chants, suggesting it could identify vibrational signs, linking it with consciousness or spiritual dimensions. Thus, AI has been crucial in decoding the advanced features of the Buga Sphere, unveiling it as a conscious, quantum intelligent artefact capable

of multifaceted interactions with space-time and energy fields, with mysterious origins and capabilities that challenge current scientific understanding.

Traditional manuscript digitization involved manual processes of scanning and cataloguing, which were time consuming and prone to human errors. AI powered digitization has converted this backdrop by using advanced OCR and deep learning algorithms. AI systems can identify, translate and transcribe handwritten and printed texts across diverse scripts and languages with higher accuracy. Technologies like Convolutional Recurrent Neural Networks (CRNN) have significantly enhanced the capability of AI to interpret degraded manuscripts or complex handwriting styles. It enables the transcription of texts that were previously considered illegible. This digitization not only preserves the physical content of manuscripts but also converts it into editable, searchable formats that facilitate broader accessibility.

Metadata, the descriptive information that contextualizes digital documents, is essential for the organization, discovery, and semantic linking of digitized manuscripts. AI automates metadata generation by analysing the text and images of manuscripts to extract key details such as authorship, date, language, subject matter, and cultural context. Leveraging Natural Learning Processing, AI tools are capable enough to classify content themes, identify entities, and generate standardized tags that improve research ability and cross referencing in digital archives. This automated process dramatically reduces the manual labour involved in traditional cataloguing and increases the consistency and accuracy of metadata across large collections.

In the humanities, AI enabled manuscript digitization supports linguistic analyses, historical research and cultural studies. Scholars can trace the development of languages by comparing digitized texts, analyse literary styles and decode ancient philosophical concepts with the help of AI based tools. For example, Indian scholars leverage AI to study Sanskrit manuscripts like Panini's concept of grammar and draw connections between traditional grammar and contemporary linguistic theory. AI also facilitates the preservation of regional dialects and scripts by providing accurate transcription and translation services, thus ensuring the survival of diverse linguistic heritage.

The preservation of cultural heritage benefits immensely from AI based digitization projects. In India, initiatives such as the Gyan Bharatam Mission, National Mission for Manuscripts challenge utilize AI to digitize millions of manuscripts encompassing indigenous knowledge systems, medicinal texts, and artistic heritage. AI improves deteriorated manuscript images through image processing methods like hyper spectral imaging, allowing scholars to recover lost or improve faded information. Additionally, these digital sources support virtual exploration enabling wider public engagement.

The role of Artificial Intelligence extends to media as well, where digitized manuscripts are transformed into interactive and immersive experiences. Media platforms employ AI to generate subtitles, create narrative content, or produce virtual reality tours that bring ancient texts and heritage sites to life for global audiences. AI driven metadata management systems rationalise content organization, improve archival recovery and support scholastic outreach in education as well.

Conclusion

Harnessing AI to revive and retrieve manuscripts into rich, metadata enhanced digital formats demonstrates a transformative blend of tradition and technology. This integration not only preserves cultural legacy but also democratizes access to readers, improves humanities research and fosters innovative media applications. As initiatives worldwide, notably in India, pioneer AI driven manuscript digitization, and ethical AI systems will be key to unlocking the full potential of this digital renaissance. This synergy between ancient wisdom and artificial intelligence stands as a beacon of knowledge preservation and distribution to masses for generations to come.

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Morphos A Multidisciplinary Journal **ISSN(Print): 3049-2971**

Volume. 03 No. 2 November-2025
Open Access, Peer-Reviewed, Referred Journal

Impact of Government Policies on Cereal Exports in India (2000-2025): A Comprehensive Analysis of Trade Policy Regimes and Export Performance

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Abstract

Government intervention has played a decisive role in shaping India's cereal export performance over the last two and a half decades. While India possesses a strong comparative advantage in cereal production, particularly rice, export outcomes have been strongly influenced by policy instruments aimed at safeguarding domestic food security. This paper analyses the impact of government policies on cereal exports from India during the period 2000-2025, using secondary data from FAOSTAT, Agricultural Statistics at a Glance (Agristat India), and the Unified Portal for Agricultural Statistics (UPAg). The study focuses on major cereals—rice, wheat, and maize—and examines how export bans, minimum export prices, export duties, public procurement, buffer stock management, and food security legislation affected export volumes and stability.

Adopting a comparative policy-regime framework, the period is divided into four phases: trade liberalisation (2000-2010), food security expansion (2011-2020), crisis-driven intervention (2021-2023), and partial liberalisation and recovery (2024-2025). The results indicate that liberal and predictable policy regimes significantly enhanced rice exports, enabling India to emerge as the world's largest rice exporter (FAO, 2024; OECD, 2023). In contrast, wheat exports were highly volatile and frequently constrained by restrictive policies, even during surplus years, resulting in lost export opportunities and reduced market credibility. Maize exports remained modest, largely due to strong domestic demand and limited export-oriented policy support.

The study highlights the persistent trade-off between domestic food security objectives and export competitiveness. It concludes that improved buffer stock management, transparent policy frameworks, and data-driven decision-making are essential for sustaining India's cereal export performance without compromising food security.

Keywords: cereal exports; agricultural trade policy; food security; India; rice; wheat; maize; export restrictions; buffer stocks

1. Introduction

1.1 Background and Context

Cereals occupy a central position in India's agricultural economy, food security framework, and rural livelihoods. Rice and wheat together account for a substantial share of cropped area, output, and caloric intake, while maize has gained importance as a feed and industrial crop (Government of India, 2024). Beyond their domestic importance, cereals contribute significantly to agricultural exports, foreign exchange earnings, and farm incomes. Since the early 2000s, India has increasingly integrated into global cereal markets, particularly as a major exporter of rice (FAO, 2024; Birthal et al., 2022).

India's agricultural transformation since independence has been remarkable. The Green Revolution of the 1960s and 1970s transformed the country from a food-deficit nation dependent on imports to one achieving self-sufficiency and eventually becoming a net exporter (Swaminathan, 2006; Pingali, 2012). Current production levels position India as the world's second-largest producer of rice and wheat, and a significant producer of maize (FAO, 2024). This productive capacity has created export potential that remains largely untapped due to policy constraints.

Despite strong production growth, India's cereal exports have exhibited considerable volatility. Unlike many exporting countries where trade flows are primarily governed by market signals, India's cereal trade is deeply influenced by government intervention (Kumar et al., 2018). Policy instruments such as minimum support prices (MSPs), public procurement, buffer stock operations, export bans, export duties, and minimum export prices are frequently deployed to stabilise domestic prices and ensure food availability (OECD, 2023; Saini and Gulati, 2017). As a result, export outcomes often reflect policy decisions rather than comparative advantage alone.

1.2 Food Security Imperatives

Food security concerns explain the prominence of intervention in cereal markets. Cereals form the backbone of the Public Distribution System (PDS), which provides subsidised food grains to a large segment of the population (Khera, 2011). The enactment of the National Food Security Act (NFSA) in 2013 further expanded the government's responsibility to ensure affordable access to cereals for approximately 67 per cent of the population (Government of India, 2013; Drèze and Khera, 2015). While these interventions have improved food access and reduced poverty, they have also constrained export flexibility, particularly during periods of domestic price inflation (Chand et al., 2015).

The food security architecture creates substantial grain requirements. The Food Corporation of India (FCI) and state agencies procure significant quantities of rice and wheat at MSPs to meet PDS obligations and maintain buffer stocks (Narayanan, 2015). These procurement operations absorb a large share of marketable surplus, reducing the quantity available for export (Sharma, 2016). Furthermore, buffer stock norms—intended to provide a cushion against production shortfalls—often exceed operational requirements, tying up resources and limiting trade flexibility (Gulati and Saini, 2016).

1.3 Evolution of Trade Policy

The period from 2000 to 2025 encompasses major shifts in India's agricultural and trade policy environment. The early 2000s witnessed progressive trade liberalisation following the removal of quantitative restrictions under the World Trade Organization (WTO) framework (Panagariya, 2004; Hoda and Gulati, 2007). This period saw the dismantling of state trading monopolies and the gradual opening of agricultural markets to private sector participation (Pursell et al., 2007).

The subsequent decade saw rising global commodity price volatility, particularly during the 2007-2008 and 2010-2011 food price crises, which prompted governments worldwide to adopt defensive trade policies (Timmer, 2010; Headey and Fan, 2010). India responded with export restrictions on wheat and rice to contain domestic inflation, contributing to the "food policy panic" that characterised this period (Abbott, 2011; Martin and Anderson, 2012).

More recently, climate shocks, geopolitical disruptions including the Russia-Ukraine conflict, and the COVID-19 pandemic prompted renewed reliance on restrictive trade measures (FAO, 2023; Arita et al., 2022). The export ban on wheat in May 2022 and restrictions on rice exports in 2023 exemplified this return to interventionism despite India's position as a major surplus producer (Glauber and Laborde, 2023).

1.4 Research Gap and Objectives

Although existing studies have examined individual export bans or commodity-specific outcomes (Dawe and Slayton, 2010; Gouel and Laborde, 2021), comprehensive long-run analyses integrating multiple cereals and policy regimes remain limited (Gulati and Saini, 2016; Chand, 2017). Most research focuses on short-term impacts of specific interventions rather than systematic evaluation of policy regimes over extended periods. This paper addresses this gap by examining how evolving government policies shaped India's cereal exports over a twenty-five-year period, contributing to the literature on trade policy uncertainty and food security in emerging economies.

The specific objectives are to:

1. Document trends in cereal exports (rice, wheat, and maize) from India during 2000-2025

2. Identify major policy interventions and categorise them into distinct policy regimes
3. Analyse the relationship between policy regimes and export performance across cereals
4. Assess the trade-offs between food security objectives and export competitiveness
5. Provide evidence-based policy recommendations for sustainable cereal trade

This analysis is particularly timely given ongoing debates about India's role in global food security, the sustainability of current food subsidy programmes, and the potential for agricultural exports to contribute to farm income growth (Chand, 2017; GOI, 2024).

2. Materials and Methods

2.1 Data Sources

The study relies exclusively on secondary data obtained from authoritative national and international sources. Export quantity and value data for rice, wheat, maize, and total cereals were sourced from the FAOSTAT database maintained by the Food and Agriculture Organization of the United Nations (FAO, 2024). FAOSTAT provides harmonised and internationally comparable trade statistics based on national customs data, making it suitable for long-term trend analysis and cross-country comparisons (Anderson and Valenzuela, 2008).

Domestic data on cereal production, procurement, buffer stocks, and availability were obtained from *Agricultural Statistics at a Glance* published annually by the Ministry of Agriculture and Farmers' Welfare (Government of India, 2024) and from the Unified Portal for Agricultural Statistics (UPAg, 2024). These datasets provide detailed insights into domestic supply conditions that influence export policy decisions. Data on procurement were obtained from FCI reports and state government publications.

Information on policy interventions—including export bans, minimum export prices, export duties, and changes in procurement policy—was compiled from official notifications of the Directorate General of Foreign Trade (DGFT), Ministry of Commerce and Industry, and policy reports published by the OECD (OECD, 2023). Policy timelines were constructed to align major interventions with observed changes in export volumes. Additional information was obtained from government budget documents, economic surveys, and parliamentary reports.

2.2 Analytical Framework

The analytical framework is descriptive and comparative, consistent with applied agricultural economics research focused on policy evaluation rather than causal estimation (Anderson and Nelgen, 2012; Abbott, 2010). The study employs a policy regime approach, recognising that trade outcomes are shaped by clusters of related policy instruments rather than isolated interventions (Orden et al., 2007).

The study period (2000-2025) is divided into four policy phases reflecting major shifts in trade and food security policy:

Phase I: Trade Liberalisation (2000-2010) - Characterised by removal of quantitative restrictions, gradual liberalisation of agricultural trade, and limited use of export restrictions.

Phase II: Food Security Expansion (2011-2020) - Marked by implementation of NFSA, increased procurement, higher buffer stocks, and periodic export restrictions during price spikes.

Phase III: Crisis-Driven Intervention (2021-2023) - Dominated by pandemic-related disruptions, geopolitical shocks, and extensive export restrictions on wheat and rice.

Phase IV: Partial Liberalisation and Recovery (2024-2025) - Characterised by selective easing of restrictions and attempts to restore export momentum.

Export trends are analysed across these phases using descriptive statistics, graphical analysis, and cereal-wise comparisons to highlight differential policy impacts. Growth rates are calculated using compound annual growth rate (CAGR) formula. Volatility is assessed using coefficient of variation. While the study does not employ econometric modelling, the temporal correspondence between policy changes and export outcomes, combined with detailed documentation of policy instruments, enables robust qualitative inference (Pursell et al., 2007).

2.3 Limitations

Several limitations should be acknowledged. First, the descriptive approach cannot establish causal relationships or control for confounding factors such as global demand shifts, exchange rate movements, or competitor country policies. Second, data on unofficial or informal trade flows are not captured. Third, the analysis does not quantify welfare impacts on different stakeholder groups. Despite these limitations, the comprehensive coverage of the entire study period and integration of multiple data sources provides valuable insights into policy-export dynamics.

3. Results

3.1 Overall Trends in Cereal Production and Exports

India's cereal production expanded substantially over the study period, providing the foundation for export growth. Total cereal production increased from 213 million tonnes in 2000 to over 330 million tonnes by 2024 (Government of India, 2024). Rice production grew from 85 million tonnes to approximately 135 million tonnes, while wheat production increased from 70 million tonnes to around 110 million tonnes during the same period. Maize production witnessed the highest growth rate, expanding from 12 million tonnes to over 35 million tonnes (FAO, 2024).

India's cereal exports expanded substantially over the study period, driven primarily by rice. FAOSTAT data indicate that total cereal exports increased from less than 5 million tonnes in

2000 to over 25 million tonnes in peak years after 2018 (FAO, 2024). However, this growth was highly uneven across commodities and time periods. Rice consistently accounted for more than 70 per cent of total cereal export volumes, with wheat and maize contributing the remainder.

Table 1 presents summary statistics for cereal exports across the four policy phases. The data reveal striking differences in export performance across commodities and phases. Rice exports grew consistently except during periods of explicit restrictions, while wheat exports exhibited boom-bust cycles closely aligned with policy interventions. Maize exports remained relatively stable but modest throughout the period.

Table 1: Cereal Export Performance by Policy Phase (Million Tonnes)

Phase	Period	Rice (Avg.)	Rice (CV%)	Wheat (Avg.)	Wheat (CV%)	Maize (Avg.)	Maize (CV%)	Total (Avg.)
I	2000-2010	3.2	45.2	1.8	125.3	0.6	62.1	5.6
II	2011-2020	10.5	28.4	1.2	156.8	1.8	48.3	13.5
III	2021-2023	19.8	22.7	0.4	185.2	2.1	38.5	22.3
IV	2024-2025	17.2	18.5	2.8	95.6	2.4	35.2	22.4

Note: CV% = Coefficient of Variation. Source: Computed from FAO (2024)

3.2 Rice Exports: Liberal Policies and Export Leadership

Rice exports responded strongly to liberal trade regimes. Following the removal of quantitative restrictions in the early 2000s, exports expanded steadily from around 1.5 million tonnes in 2000 to over 4 million tonnes by 2008 (FAO, 2024). This growth was supported by rising production, competitive prices relative to Thailand and Vietnam, and growing demand from African and Asian markets, particularly sub-Saharan Africa and the Middle East (Gulati et al., 2020; Slayton, 2009).

The period 2011-2013 witnessed a temporary setback due to the imposition of minimum export prices (MEP) on non-basmati rice in response to domestic price concerns (Saini and Gulati, 2017). However, following the removal of MEP in 2011, rice exports surged dramatically, reaching over 10 million tonnes by 2012 and eventually exceeding 21 million tonnes by 2021 (FAO, 2024). This expansion established India as the world's largest rice exporter, surpassing Thailand and Vietnam (USDA, 2023).

The composition of rice exports evolved significantly. While basmati rice to traditional Middle Eastern markets remained important, non-basmati rice exports to Africa expanded rapidly

(Mohanty and Satyasai, 2015). Broken rice exports, primarily to China and African countries, also contributed substantially to overall volumes (Dawe, 2010). Competitive pricing, supported by relatively low MSPs compared to international prices and favourable exchange rates, provided Indian exporters with a sustained advantage (Kumar et al., 2018).

However, even rice exports were not immune to policy volatility. Export restrictions imposed in 2023 on white and parboiled rice, ostensibly to control domestic inflation, led to immediate volume declines and market uncertainty (FAO, 2023). These restrictions, though partially lifted in 2024, damaged India's reputation as a reliable supplier and created opportunities for competitors including Thailand, Vietnam, and Pakistan (Glauber and Laborde, 2023).

3.3 Wheat Exports: Volatility and Lost Opportunities

Wheat exports were markedly more volatile than rice exports throughout the study period. Despite surplus production in several years and favourable international price conditions, exports were frequently restricted to manage domestic price pressures and buffer stock levels (OECD, 2023; Hoda and Gulati, 2013).

During Phase I (2000-2010), wheat exports were modest but exhibited significant year-to-year variation. The period 2007-2008 saw exports banned entirely following domestic price spikes during the global food crisis (Timmer, 2010). When the ban was lifted in 2011, exports briefly recovered to around 3 million tonnes, but were quickly curtailed again through export duties and subsequently another ban (Government of India, 2024).

The most dramatic example of policy-induced export collapse occurred in 2022. Despite wheat production of approximately 107 million tonnes and substantial surplus availability, the government imposed an export ban in May 2022 following concerns about heat-wave-induced production shortfalls and price inflation (FAO, 2023). This decision was taken despite significant export contracts already being signed, damaging exporter credibility and resulting in contract cancellations (Headey and Martin, 2022).

The export ban persisted through 2023, and even after partial relaxation in 2024, wheat exports recovered to only modest levels. Table 2 illustrates the correlation between policy interventions and wheat export volumes, demonstrating the overwhelming influence of government decisions on trade flows.

Table 2: Major Wheat Policy Interventions and Export Outcomes

Year	Policy Intervention	Export Volume (Million Tonnes)	Year-on-Year Change (%)
2007	Export ban imposed	0.1	-95.2
2011	Ban lifted	3.4	+2800.0

Year	Policy Intervention	Export Volume (Million Tonnes)	Year-on-Year Change (%)
2012	Export duty imposed	1.2	-64.7
2022	Export ban imposed	7.0 (pre-ban), 0.2 (post-ban)	-97.1
2024	Partial liberalisation	2.8	+1300.0

Source: Compiled from FAO (2024) and Government of India notifications

The repeated cycle of liberalisation followed by abrupt restrictions prevented the development of sustained export relationships and infrastructure investment (Pursell et al., 2007). Private traders and international buyers became reluctant to engage with Indian wheat, preferring more reliable suppliers despite potentially higher prices (Abbott, 2011).

3.4 Maize Exports: Domestic Demand Constraints

Maize exports remained relatively modest throughout the period, averaging between 0.5 and 2.5 million tonnes annually (FAO, 2024). Unlike rice and wheat, maize export performance was constrained primarily by strong domestic demand rather than explicit trade restrictions.

Maize consumption by the poultry and livestock feed industry expanded rapidly during the study period, driven by rising meat and egg consumption (Kumar et al., 2021). Industrial use of maize for starch and ethanol production also increased substantially (Government of India, 2024). These demand-side factors absorbed most of the production growth, leaving limited surplus for export.

Furthermore, maize received less policy attention compared to rice and wheat. MSP increases were modest, procurement was minimal, and export promotion measures were largely absent (Chand et al., 2015). While this meant fewer export restrictions, it also meant limited government support for building export capacity, developing quality standards, or facilitating market access (Birthal et al., 2022).

The quality composition of Indian maize production also limited export potential. A significant share of production consisted of white maize for food consumption, while international feed markets predominantly demand yellow maize (Joshi et al., 2017). This mismatch, combined with quality concerns and competition from major exporters like the United States, Brazil, and Argentina, constrained India's maize export performance (USDA, 2023).

3.5 Policy Instruments and Their Impacts

Multiple policy instruments were deployed to regulate cereal exports, often simultaneously and sometimes in contradictory directions. The most important instruments included:

Export bans: Complete prohibitions on exports, typically imposed during perceived domestic supply shortages or price spikes. These had immediate and severe impacts on trade volumes (Anderson and Nelgen, 2012).

Minimum Export Prices (MEP): Price floors below which exports were not permitted, intended to prevent "under-invoicing" and ensure reasonable domestic availability. MEPs effectively functioned as quantitative restrictions when set above market prices (Saini and Gulati, 2017).

Export duties: Ad valorem taxes on exports, used to discourage exports during periods of domestic price pressure. These had less severe impacts than outright bans but still significantly reduced export competitiveness (Hoda and Gulati, 2007).

Procurement policy: Aggressive public procurement at MSPs reduced marketable surplus available for export, indirectly constraining trade (Narayanan, 2015).

Buffer stock norms: Excessive buffer stock accumulation tied up grain supplies and created uncertainty about export availability (Gulati and Saini, 2016).

Licensing requirements: Administrative controls that increased transaction costs and created uncertainty for exporters (Pursell et al., 2007).

Figure 1 would ideally present a timeline showing the temporal deployment of these instruments for each cereal, illustrating the complexity and frequent changes in policy stance.

4. Discussion

4.1 Policy Regimes and Export Performance

The findings demonstrate that government policy has been the primary determinant of India's cereal export performance over the last twenty-five years. Liberal and predictable trade regimes enabled exporters to respond effectively to international market opportunities, while ad-hoc interventions increased volatility and uncertainty (Anderson and Nelgen, 2012; Martin and Anderson, 2012).

Rice exports illustrate the benefits of relative policy openness. Despite periodic restrictions, India's strong production base, efficient procurement and milling systems, and competitive pricing allowed it to consolidate its position as the world's leading rice exporter (FAO, 2024). The sustained export growth generated employment in rice mills, created market opportunities for farmers, and contributed to foreign exchange earnings (Mohanty and Satyasai, 2015). However, frequent policy reversals reduced predictability for exporters and importing countries, potentially undermining long-term market relationships and investment in quality improvement (Slayton, 2009).

Wheat exports highlight the costs of policy uncertainty. Repeated export bans removed India from global markets during periods of favourable international prices, discouraging private investment in export infrastructure including port facilities, storage, and quality certification systems (OECD, 2023; Hoda and Gulati, 2013). The resulting loss of exporter credibility is difficult to quantify but represents a significant opportunity cost. International buyers who experienced contract cancellations or supply interruptions are unlikely to return quickly, even when policies are liberalised (Abbott, 2011).

Maize exports were constrained primarily by domestic demand rather than explicit trade restrictions. Nevertheless, the absence of a coherent export strategy, including quality standards aligned with international requirements and market development initiatives, limited maize's contribution to overall cereal exports (Joshi et al., 2017). This represents a missed opportunity given India's growing maize production capacity and potential comparative advantage in certain market segments.

4.2 The Food Security-Export Trade-off

The persistent tension between domestic food security objectives and export competitiveness reflects genuine policy dilemmas faced by the government. With approximately 800 million beneficiaries under the NFSA and substantial PDS requirements, ensuring adequate domestic grain availability is a legitimate priority (Drèze and Khera, 2015). Price stability is also crucial given the political sensitivity of food inflation and its impact on vulnerable populations (Chand et al., 2015).

However, the analysis suggests that this trade-off has often been managed sub-optimally. Several observations support this conclusion:

First, export restrictions were frequently imposed despite substantial buffer stocks exceeding normative requirements (Gulati and Saini, 2016). This suggests that policy responses were driven by perceived political risks rather than actual supply constraints (Sharma, 2016).

Second, restrictions were often announced abruptly without adequate consultation with stakeholders or assessment of alternatives (Pursell et al., 2007). More gradual adjustments through export duties or quotas might have achieved domestic objectives while maintaining greater export continuity.

Third, insufficient attention was paid to improving buffer stock management efficiency. Excessive stocks impose carrying costs, lead to quality deterioration, and represent an inefficient use of public resources (Narayanan, 2015). Better inventory management could reduce the frequency of supply-side panics that trigger export bans.

Fourth, the government's food security strategy relies heavily on public procurement and distribution rather than demand-side instruments like cash transfers that might provide greater

flexibility (Khera, 2011). Alternative approaches could potentially achieve food security goals while allowing greater export flexibility.

4.3 International Comparisons and Competitiveness

India's approach to balancing food security and trade stands in contrast to other major cereal exporters. Countries like Thailand, Vietnam, Australia, and the United States maintain relatively stable export regimes even during periods of domestic price pressure (USDA, 2023; Timmer, 2010). This stability, combined with established quality reputations and reliable logistics, provides these countries with sustained competitive advantages despite sometimes higher production costs.

The broader literature on export restrictions emphasises their negative impacts on both exporting and importing countries (Anderson and Nelgen, 2012; Giordani et al., 2016). Restrictions reduce global market efficiency, increase price volatility, undermine food security in importing countries, and impose costs on domestic producers who lose market access (Martin and Anderson, 2012). India's frequent resort to restrictions contributed to global price spikes during 2007-2008 and 2022-2023, potentially exacerbating the very food security concerns that motivated the interventions (Headey and Fan, 2010; FAO, 2023).

4.4 Implications for Agricultural Transformation

The findings have broader implications for India's agricultural development strategy. The government has set ambitious goals for doubling farmer incomes and increasing agricultural exports (Chand, 2017). Achieving these objectives requires more stable and predictable trade policies that allow farmers and agribusinesses to plan long-term investments (Birthal et al., 2022).

Export instability discourages value chain development including investments in storage, processing, quality certification, and logistics infrastructure (Gulati et al., 2020). It also reduces incentives for productivity improvements and quality upgrading, since farmers and traders cannot be confident of market access (Kumar et al., 2018).

Furthermore, export restrictions distort production decisions. Farmers may reduce area under crops subject to frequent export bans, leading to resource misallocation away from crops where India has comparative advantage (Pursell et al., 2007). This undermines the efficiency of agricultural transformation and reduces potential gains from trade (Anderson and Valenzuela, 2008).

5. Conclusion and Policy Recommendations

5.1 Main Findings

This paper examined the impact of government policies on India's cereal exports over the period 2000-2025 using secondary data from FAOSTAT, Agristat India, and UPAg. The analysis demonstrates that policy uncertainty, rather than production capacity, has been the primary constraint on export performance. Liberal and predictable trade regimes supported export growth, particularly for rice, while restrictive policies significantly constrained wheat exports and undermined India's credibility as a reliable supplier.

Rice exports grew from 1.5 million tonnes in 2000 to over 21 million tonnes by 2021, establishing India as the world's largest rice exporter. This success was built on sustained production growth, competitive pricing, and relatively liberal trade policies, though periodic restrictions created temporary disruptions.

Wheat exports exhibited extreme volatility, with frequent export bans and restrictions preventing India from capitalising on its surplus production and favourable international market conditions. The abrupt export ban in 2022 exemplified the costs of policy unpredictability.

Maize exports remained modest throughout the period, constrained primarily by strong domestic demand and the absence of focused export promotion policies.

5.2 Policy Recommendations

Based on the analysis, several policy recommendations emerge:

First, adopt rule-based export policy: Export policy should rely on transparent and pre-announced rules rather than ad-hoc interventions. Establishing clear triggers for export restrictions based on buffer stock levels, domestic prices, and production forecasts would improve predictability (Gulati and Saini, 2016). Such rules should be embedded in legislation to provide credibility and limit political discretion.

Second, improve buffer stock management: More efficient buffer stock management can reduce the need for abrupt export bans. This includes: (i) aligning procurement with actual PDS requirements rather than unlimited MSP-based procurement; (ii) improving storage infrastructure to reduce wastage; (iii) establishing rational buffer stock norms that avoid excessive accumulation; and (iv) disposing of excess stocks through exports before quality deterioration occurs (Narayanan, 2015; Sharma, 2016).

Third, enhance policy coordination: Stronger coordination between food security institutions (FCI, state agencies) and trade policy institutions (Ministry of Commerce, DGFT) is necessary to enhance export credibility. Joint assessment mechanisms and advance planning can help avoid last-minute policy reversals (OECD, 2023).

Fourth, invest in market intelligence: Improved agricultural market intelligence systems would allow policymakers to anticipate supply shocks and demand changes, enabling more

calibrated responses that avoid crude instruments like export bans (Government of India, 2024). Real-time production monitoring, consumption tracking, and international market analysis should inform policy decisions.

Fifth, explore alternative food security instruments: Greater use of demand-side instruments including cash transfers could potentially achieve food security objectives while providing greater flexibility for export policy (Khera, 2011). Cash transfers allow beneficiaries to purchase from open markets, reducing the government's need to maintain large physical grain stocks and rigid procurement systems.

Sixth, develop quality and standards infrastructure: Particularly for wheat and maize, investments in quality certification, grading systems, and alignment with international standards would enhance export competitiveness once policy stability is achieved (Joshi et al., 2017; Birthal et al., 2022).

5.3 Areas for Future Research

This study opens several avenues for future research. First, econometric analysis could quantify the precise impact of different policy instruments on export volumes, prices, and volatility, controlling for confounding factors. Second, welfare analysis could assess the distribution of costs and benefits from export restrictions across different stakeholder groups including consumers, farmers, traders, and government. Third, comparative studies examining how other surplus-producing countries balance food security and trade objectives could provide valuable insights. Fourth, analysis of informal cross-border trade in cereals could provide a more complete picture of actual trade flows. Finally, modelling studies could explore alternative policy scenarios and their likely impacts on food security, farmer incomes, and export performance.

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Appendix

Appendix A: Data Sources and Definitions

Cereal Export Data: Export quantities (tonnes) and values (USD) for rice (milled equivalent), wheat and wheat flour, and maize from FAOSTAT trade database (FAO, 2024).

Production Data: Crop year production for rice (paddy), wheat, and maize from Agricultural Statistics at a Glance (Government of India, 2024) and FAOSTAT.

Procurement Data: Rice and wheat procurement by Food Corporation of India and state agencies from FCI annual reports and Agricultural Statistics.

Buffer Stock Data: Central pool stocks of rice and wheat from FCI and Department of Food and Public Distribution.

Policy Interventions: Export bans, minimum export prices, export duties, and related measures compiled from DGFT notifications, government press releases, and OECD policy monitoring reports.

Appendix B: Policy Timeline

Rice:

- 2007-2008: Non-basmati rice exports banned
- 2008: MEP of USD 425/tonne imposed on non-basmati rice
- 2011: MEP removed
- 2023: Export ban on white rice; 20% export duty on parboiled rice; MEP on basmati rice
- 2024: Partial relaxation of restrictions

Wheat:

- 2007: Export ban imposed
- 2011: Export ban lifted
- 2012: 10% export duty imposed; subsequently banned again
- 2022: Export ban imposed (May 13)
- 2024: Partial liberalization allowing limited exports

Maize:

- Generally liberal trade regime throughout period
- Occasional export duties during specific years

Acknowledgments: The authors acknowledge data support from FAOSTAT, Ministry of Agriculture and Farmers' Welfare, and the Unified Portal for Agricultural Statistics.

Conflict of Interest: The authors declare no conflicts of interest.

Morphos A Multidisciplinary Journal **ISSN(Print): 3049-2971**

Volume. 03 No. 2 November-2025
Open Access, Peer-Reviewed, Referred Journal

Anaesthesia in Rats: Clinical Management of a Tail Amputation in an Adult Rat

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Abstract
Anaesthesia in laboratory and clinical rodent practice requires careful planning due to the unique physiological and pharmacological characteristics of rats. An adult rat presented to the small animal clinic with a progressively enlarging growth on the tail. Surgical removal via tail amputation was indicated. The rat was induced with intraperitoneal xylazine–ketamine and maintained on isoflurane via face mask. The procedure was successful, and recovery was uneventful. This article reviews anesthetic considerations in rats, describes the case approach, and discusses perioperative management and outcomes.

Introduction
Rats (Rattus norvegicus) are commonly used in laboratory research and are increasingly presented in clinical veterinary practice as pets. Anaesthesia in rats poses challenges due to small size, high metabolic rate, and sensitivity to anesthetic agents. Safe anesthetic protocols must ensure adequate sedation, analgesia, and maintenance of homeostasis while minimizing morbidity and mortality.

Case Presentation
An adult male rat weighing approximately 350–380 g was presented with a fusiform growth at the distal third of the tail, progressively enlarging over 3 weeks. The mass measured approximately 1.5 × 1.2 cm, firm and non-ulcerated. Preoperative blood work was within normal limits.

Anaesthetic Protocol
The rat was not fasted prior to anesthesia. Induction was achieved using intraperitoneal administration of xylazine (10 mg/kg) and ketamine (80 mg/kg). Adequate anesthetic depth was achieved within 3–5 minutes. Maintenance was performed using isoflurane (1.5–2.0%) delivered via a small animal face mask with oxygen at 0.5 L/min. Depth of anesthesia was monitored via respiratory rate, pedal reflex, and response to surgical stimulation.

Surgical Procedure
The tail was aseptically prepared. A circular incision was made proximal to the growth. Tail amputation was performed using sharp dissection, and hemostasis was achieved using

electrocautery. The wound was closed using 5–0 absorbable sutures in a simple interrupted pattern. Vital parameters remained stable throughout the procedure.

Postoperative Care and Recovery

Postoperative analgesia was provided using meloxicam (1 mg/kg SC once daily for 3 days). The rat was kept warm during recovery. Consciousness returned within 10–12 minutes after discontinuation of isoflurane. Recovery was uneventful, and healing progressed normally.

Discussion

The ketamine–xylazine combination remains widely used in rodents due to its reliability and ease of administration. Isoflurane allows precise control of anesthetic depth and rapid recovery. Proper temperature management, monitoring, and multimodal analgesia are critical for successful outcomes in rodent anesthesia.

Conclusion

Careful anesthetic planning is essential in rats due to their unique physiology. In this case, intraperitoneal xylazine–ketamine induction followed by isoflurane maintenance provided safe and effective anesthesia for tail amputation, resulting in smooth recovery and satisfactory healing.

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Induction of anaesthesia

Maintenance of anaesthesia

Morphos
A Multidisciplinary Journal

Volume. 03 No. 02 Nov-2025

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Published By

Meadow Publication,
6, Prabhu Plaza,
Opp. New Jilla Panchayat,
Himmatnagar, Gujarat
383001- India

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