 ***DOI:*** *https://doij.org/10.10000/IJLMH.119677*

# INTERNATIONAL JOURNAL OF LAW MANAGEMENT & HUMANITIES

**[ISSN 2581-5369]**

**Volume 8 | Issue 3**

**2025**

# Analysing the Intersection of Science, Technology and Forensic Evidence in India

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## ABSTRACT

*Science and technology, like law, are ever dynamic, and their integration in the realm of forensic science has become indispensable. Technological advancements help in reaching higher standards of forensic investigation and speeding up the entire process while also making it more efficient. However, the application and acceptance of these new forensic technologies has been inconsistent and underdeveloped in India. Despite legislative reforms and the introduction of the new criminal laws, the practical implementation faces significant roadblocks.*

*This paper examines the intersection of science, technology, and forensic evidence in light of the Indian legal framework, along with a focus on the ethical dilemmas and challenges that arise. It critically analyses the implications of integrating Artificial Intelligence and other emerging technologies in forensic procedures so as to address concerns related to data integrity, privacy, and algorithmic bias. Drawing comparisons with established forensic practices in jurisdictions such as the United States, the United Kingdom, Australia, and Canada, this research highlights the gaps in India's forensic infrastructure, including outdated technology, insufficient funding, and a lack of standardised procedures. Additionally, the paper explores the importance of public awareness and institutional support in realising the full potential of forensic science, along with training programs, international collaboration, and the development of clear ethical and legal standards to ensure that forensic evidence is both reliable and admissible.*

***Keywords:*** *science, technology, forensic evidence, artificial intelligence.*

## I. INTRODUCTION

*"Law and technology produce, together, a kind of regulation of creativity we've not seen before."*

\- *Lawrence Lessig*

While it is open knowledge that technology, in most of its forms, helps us out in various aspects of life, be it an everyday task or an exquisite expedition; it is often observed that in the field of law, especially relating to evidence, technological advancements are not being accepted or used

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so widely. Even though improving, regulating and reorganizing the technologies provides us with the avenues and benefits of enhancing internal security, assisting law enforcement agencies in criminal investigations, helping criminal justice administration, providing proactive assistance and reducing the risk of wrongful conviction or exoneration; it is not being utilized to its fullest.[2]

In terms of forensic sciences and the evidence that spring out from it, India stands to be in a state of crisis. While the **Bharatiya Sakshya Adhiniyam, 2023**[3] (hereinafter BSA) has tried to incorporate electronic and scientific evidence into the realm of the criminal justice system and aims to provide for development in this sector; it is understandable that the Indian judiciary will take time to embrace it and accept it completely. We are aware that any change in India takes a lot of time to be accepted and even more time to be finally implemented. So even if the black letter law states that these must be taken into consideration, till the time action is not really taken on ground level, no improvements would be seen. With the rapid advancement of science and interdisciplinary technology, investigations today demand complex evidence collection processes and crime scene analysis to arrive at scientifically precise and unbiased conclusions. Thus, making technology an inevitable and essential part of the forensic evidences.

On the face of it, forensic evidence means evidence that is derived from the use of a field of science or the scientific method in order to investigate and prove crimes.[4] It is the physical evidence found at the crime scene.[5] Therefore, forensic evidence encompasses within it a broad range of disciplines, i.e., softer fields like psychology or social sciences as well as harder methods like biology or chemistry. ""Forensic evidence" thus includes everything from a DNA match to a mental illness diagnosis to the results of a study that reveals cognitive biases in eyewitness identification."[6] Such a piece of evidence is considered as secondary evidence, the documents being the primary evidence. The primary evidence amalgamated with secondary evidence is presented in the court of law, which helps the court to understand the facts and deliver the judgment.[7]

[2] Dr. T. R. Baggi, *Why is forensic science stunted and static in India?*, The Hindu (Sept. 11, 2011), https://www.thehindu.com/opinion/open-page/why-is-forensic-science-stunted-and-static-in-india/article2442491.ece.
[3] Bharatiya Sakshya Adhiniyam, 2023.
[4] Erin Murphy, *Forensic Evidence*, https://law.asu.edu/sites/default/files/pdf/academy_for_justice/8_Reforming-Criminal-Justice_Vol_3_Forensic-Evidence.pdf.
[5] N V Krishnakumar, *Prudent to Use Forensic Evidence, to Decide Cases Justly and Conclusively*, The Leaflet (Nov 18, 2020), https://theleaflet.in/prudent-to-use-forensic-evidence-to-decide-cases-justly-and-conclusively/.
[6] *Supra* note 3.
[7] *Supra* note 4.

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## II. LEGAL FRAMEWORK AND JUDICIAL PRONOUNCEMENTS

### A. Statutory and Jurisprudential Framework

As per **Black's Law Dictionary**[8], *"Evidence, broadly defined, is the means from which an inference may logically be drawn as to the existence of a fact; that which makes evident or plain. Evidence is the demonstration of a fact; it signifies that which demonstrates, makes clear, or ascertains the truth of the very fact or point in issue, either on the one side or on the other. In legal acceptation, the term 'evidence' includes all the means by which any alleged matter of fact, the truth of which is submitted to investigation, is established or disproved. 'Evidence' has also been defined to mean any species of proof legally presented at the trial of an issue, by the act of the parties and through the medium of witnesses, records, documents, concrete objects, and the like."*[9]

The **Indian Evidence Act, 1872**[10] was the first law in India that recognized the admissibility of scientific evidence in courts under **S. 45**[11] of the Act as opinions of experts. Forensic science and related evidence in India are governed by laws and regulations[12] like Bharatiya Nagrik Suraksha Sanhita, 2023[13] (hereinafter BNSS), BSA[14] and the Narcotic Drugs and Psychotropic Substances Act, 1985[15]. Different kinds of evidence are handled by the Central Forensic Science Laboratories (CFSLs), State Forensic Science Laboratories (SFSLs), and District Forensic Science Laboratories (DFSLs). They are arranged into discrete categories, including general chemistry, explosives, toxicology, serology, drugs, ballistics, DNA, and computer forensics.[16] Currently, India lacks a coherent and all-encompassing legal structure to supervise its activities and guarantee compliance with stringent SOPs and protocols.[17]

According to revamped law, the BSA, evidence has been defined in **S. 2(e)**[18] and has been broadly classified into oral and documentary evidence. **S. 2(e)(i)**[19] defines oral evidence as meaning and including "*all statements including statements given electronically which the*

[8] Bryan K Graner, Black's Law Dictionary, 9th ed., 2009.
[9] Bryan K Graner, Black's Law Dictionary, 635, 9th ed., 2009.
[10] Indian Evidence Act, 1872.
[11] Indian Evidence Act, 1872, § 45.
[12] Ambily P., Ashna D. *"Faulty Foundations: A Socio-Legal Critique of the Regulation of Forensic Science Laboratories in India"*, 7.2 NLUJ LR (2021).
[13] Bharatiya Nagrik Suraksha Sanhita, 2023.
[14] *Supra* note 2.
[15] Narcotic Drugs and Psychotropic Substances Act, 1985.
[16] Vishal Kumar, *Forensic Law Forensic Science Law in India*, Manupatra Academy, https://manupatracademy.com/LegalPost/Forensic_Law_Forensic_Science_Law_in_India#2.
[17] *Ibid.*
[18] Bharatiya Sakshya Adhiniyam, 2023, § 2(e).
[19] Bharatiya Sakshya Adhiniyam, 2023, § 2(e)(i).

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*Court permits or requires to be made before it by witnesses in relation to matters of fact under inquiry*"[20] and **S. 2(e)(ii)[21]** defines documentary evidence as meaning and including "*all documents including electronic or digital records produced for the inspection of the Court*".[22] Thus, the BSA aims to modernize the Indian legal system by incorporating electronic and scientific evidence.

BSA acknowledges that digital records and forensic evidence are indispensable in modern legal proceedings. It ensures that electronic and digital records are given the same legal effect, validity, and enforceability as traditional documents, provided they meet specific criteria.[23] This includes ensuring that the information was regularly inputted into the computer or communication device used to produce the record, maintaining that the device was operating properly during the relevant period, and verifying that the information in the record is consistent with the data fed into the device during regular activities.[24] This framework helps integrate technological advancements into forensic evidence collection and presentation, enhancing the reliability and credibility of such evidence in court.[25]

In practical terms, this means that electronic records, such as digital documents and multimedia files, can be admitted in court without the need for further proof or production of the original, as long as they meet the conditions specified in the BSA. This includes ensuring the records were produced during regular usage of the device for lawful activities, that the device was functioning correctly, and that the data was inputted in the ordinary course of business. Additionally, a certificate must be provided with the electronic record, detailing how it was produced and affirming its authenticity.[26] This statutory framework ensures that forensic evidence derived from electronic sources is treated with the same rigor as traditional evidence, thus enabling the legal system to leverage the full potential of modern forensic science and technology in criminal investigations and trials.

Furthermore, **S. 176(3) of BNSS**[27] mandates forensic evidence to be collected and recorded for the entire investigation process using videography on mobile phone or any other electronic device on the receipt of every information relating to the commission of an offence that is made

[20] *Ibid.*
[21] Bharatiya Sakshya Adhiniyam, 2023, § 2(e)(ii).
[22] *Ibid.*
[23] Bharatiya Sakshya Adhiniyam, 2023, § 61.
[24] Bharatiya Sakshya Adhiniyam, 2023, § 63(2)(a), (b).
[25] Bharatiya Sakshya Adhiniyam, 2023, § 63(1).
[26] Bharatiya Sakshya Adhiniyam, 2023, § 63(4).
[27] Bharatiya Nagrik Suraksha Sanhita, 2023, § 176(3).

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punishable for 7 years or more.[28]

### B. Judicial Pronouncements and Judicial Dicta

In a democratic society like ours, legitimacy has always been considered as the hallmark of the justice system with judges serving as the backbone. Over time, technological advancements have been gradually incorporated and accepted into the judicial system to ensure fair trials and thus, deliver accurate verdicts. Landmark cases have emphasized its role in corroborating facts and eliminating doubts, reflecting the judiciary's commitment to integrating reliable, scientifically-backed evidence into the legal process.

The case of ***Sushil Sharma v. State of Delhi***[29], also known as the **1995 Tandoor Murder Case**, was one of the first cases where forensic evidence was used, specifically DNA testing, to prove beyond reasonable doubt that the accused was guilty of murder.

Various technological and scientific techniques like Brain Mapping, Narco-Analysis and Polygraphic tests were used in the **Sister Abhaya Murder Case**[30], where 2 priests were convicted for rape and murder.

The Supreme Court has also emphasized on the importance of electronic evidence and highlighted that advancements in technology must be leveraged to aid criminal investigations. The Court acknowledged that the Indian legal system must adapt to incorporate modern forensic methods to ensure justice.[31]

In the recent case of ***Virendra Khanna v. State of Karnataka***[32], the court ruled that digital forensic evidence from smartphones or emails must be proven during trial and exceeds a mere specimen under **Section 311-A of Code of Criminal Procedure, 1973**[33]. Requiring passwords or biometrics isn't testimonial compulsion or self-incrimination, as the data requires trial verification. The Court affirmed that using digital evidence in investigations doesn't violate privacy rights, falling under the *Puttaswamy judgement*[34] exceptions.

## III. COMPARATIVE STUDY

In India, forensic evidence is becoming increasingly significant, but there are notable challenges in terms of technology and infrastructure. BSA provides the legal framework for the

[28] *Ibid.*
[29] *Sushil Sharma v. State of Delhi* (2014) 4 SCC 317.
[30] *In Re: Sr. Abaya v. Unknown*, 2006 CRI LJ 3843.
[31] *Tomaso Bruno and Another v. State of Uttar Pradesh*, 2015 (7) SCC 178.
[32] *Virendra Khanna vs. State of Karnataka*, WP No. 11759/2020.
[33] The Code of Criminal Procedure, 1973, § 311-A.
[34] *K.S. Puttaswamy and Anr. vs. Union of India*, (2017) 10 SCC 1.

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admissibility of forensic evidence, but its interpretation and application can be inconsistent. Indian forensic laboratories often face issues with outdated technology and a lack of standardized practices, which can affect the reliability of forensic evidence. Despite these hurdles, advancements in digital forensics and the adoption of new technologies are gradually improving the situation, making forensic evidence a crucial tool in the Indian legal system.

**The United States** has a well-established system for the admissibility of forensic evidence, primarily governed by the Daubert standard and the Frye test. The Daubert standard, originating from the ***Daubert v. Merrell Dow Pharmaceuticals case***[35], emphasizes the reliability and relevance of scientific evidence, requiring that it be peer-reviewed and generally accepted within the scientific community. The **Frye test**[36], still used in some states, focuses on the general acceptance of the scientific technique. Advanced forensic technologies, such as digital forensics, forensic toxicology, and ballistic analysis, are widely used, ensuring that forensic evidence is both relevant and reliable. The U.S. legal system's rigorous standards and technological advancements set a high bar for forensic science.[37]

**England** is renowned for its effective integration of forensic science into its legal system, particularly since the establishment of the National DNA Database in 1995.[38] The country utilizes various forensic technologies, including digital forensics, trace evidence analysis, and forensic pathology, to solve crimes and support legal proceedings. English courts balance forensic evidence with common law principles, ensuring that it is both admissible and reliable. The Law Commission has also proposed reforms to further clarify the process of admitting forensic evidence, demonstrating England's commitment to maintaining high standards in forensic science.[39]

**Australia's** approach to forensic evidence is similar to that of England and the United States,[40] but it has its unique aspects. Australian courts have been cautious in accepting forensic evidence, focusing on the reliability and relevance of the scientific methods used. Landmark cases like ***R. v. Tran***[41] and ***R. v. Lucas***[42] highlight the importance of providing detailed and

[35] *Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993).
[36] *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).
[37] Dr. Ashu Dhiman, Param Bhamra, *Evidentiary Value of Forensic Reports and Legal Implications*, Vol 2, NFSU Journal of Forensic Justice (2023).
[38] Pia Struyf, Tom Vander Beken, *The effectiveness of DNA databases in relation to their purpose and content: A systematic review*, Forensic Science International (2019).
[39] González-Rodríguez, Jose & Baron, Mark, *Forensic science in UK. Part III: Regulation of Forensic Science in England and Wales: The role of the Forensic Science Regulator*, Forensic Science Review, 2-6 (2020).
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[41] *R. v. Tran*, 1994 CanLII 56 (SCC).
[42] *R. v. Lucas*, [1998] 1 SCR 439.

accurate forensic reports. The Australian legal system values technologies such as forensic entomology, toxicology, and digital forensics, ensuring that expert testimony is relevant and probative. This cautious approach ensures forensic evidence is thoroughly scrutinized before being admitted in court.[43]

**Canada** takes a liberal approach to the admissibility of forensic evidence, focusing on relevance and the helpfulness of expert testimony. The Supreme Court of Canada's decision in ***R. v. Mohan***[44] established criteria for admitting expert evidence, including relevance, necessity, the absence of exclusionary rules, and the qualifications of the expert. Canadian courts do not strictly follow the Frye test but consider its principles when evaluating scientific evidence. Technologies such as forensic odontology, cyber forensics, and forensic anthropology are crucial in the Canadian legal system, ensuring that forensic evidence aids in the pursuit of justice without causing undue prejudice.[45]

While forensic evidence is critical in criminal justice systems worldwide, the standards and practices for its admissibility vary significantly. These differences highlight the importance of developing vigorous legal frameworks and adopting advanced technologies to ensure the effective use of forensic evidence in the pursuit of justice.

## IV. CRITICAL ANALYSIS

In the digital age, the intersection of scientific technology and forensic evidence is revolutionizing criminal investigations and judicial processes worldwide. In India, despite legal advancements like BSA, integrating technology into forensic science remains a significant challenge. India's forensic science infrastructure faces several challenges. Outdated technology, lack of standardized practices, and resource constraints hamper the effectiveness and reliability of forensic evidence.

Artificial Intelligence (hereinafter AI) has the potential to transform forensic science by enhancing accuracy, efficiency, and reliability. AI can assist in various areas, such as digital forensics, DNA analysis, and predictive policing. In digital forensics, AI algorithms can analyse vast amounts of digital data quickly, identifying patterns and anomalies that may be crucial to investigations. AI can expedite DNA sequencing and comparison processes, leading to faster identification of suspects.[46] In predictive policing, AI can help predict potential crime hotspots

[43] *Supra* note 39.
[44] *R. v. Mohan*, (1994) 166 N.R. 245 (SCC).
[45] Forensic Science in Canada: A Report of Multidisciplinary Discussion (2013), https://www.crime-scene-investigator.net/forensic-science-in-canada.pdf.
[46] Maari, Subash, Jayarraman, Ghayathri, *The Impact of New Technologies on Forensic Science*, (2023).

by analysing historical crime data, enabling law enforcement agencies to allocate resources more effectively. The integration of AI into forensic science offers several benefits, including enhanced accuracy, increased efficiency, and cost-effectiveness. AI can minimize human error in forensic analysis, ensuring more reliable results. Automation of routine tasks allows forensic experts to focus on more complex aspects of investigations. AI systems, once implemented, can reduce long-term operational costs by streamlining processes and reducing the need for extensive manpower.[47]

While AI and other technologies offer numerous benefits, over-reliance on them poses several risks. AI systems can inherit biases present in the data they are trained on, potentially leading to biased outcomes in forensic analysis. The extensive use of digital forensics and surveillance technologies raises significant privacy issues. Ensuring data integrity and protecting individual privacy are paramount. Dependence on technology makes forensic investigations vulnerable to technical failures and cyber-attacks, which could compromise the integrity of evidence. The rapid advancement of technology necessitates continuous training for forensic professionals. A lack of adequately trained personnel can impede the effective use of AI in forensic investigations.[48]

In addition to this, because integration and reliance on technology poses drawbacks as well, India must also focus on developing a robust and all-encompassing data protection laws and schemes where privacy and protection of the citizens and their information is given paramount importance. The integration of advanced forensic technologies in India requires robust legal frameworks and ethical guidelines. Ensuring the reliability and admissibility of AI-generated evidence necessitates stringent standards and protocols.[49] The BSA and the BNSS attempt to address these issues, but further refinement and practical implementation are crucial. Ethical considerations include data integrity, bias mitigation, and privacy protection. Ensuring the authenticity and integrity of digital evidence is paramount. Developing unbiased AI algorithms to prevent discriminatory practices is essential. Balancing the need for forensic investigation with individuals' privacy rights is critical.[50]

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[47] Kloosterman A, Mapes A, Geradts Z, van Eijk E, Koper C, van den Berg J, Verheij S, van der Steen M, van Asten A., *The interface between forensic science and technology: how technology could cause a paradigm shift in the role of forensic institutes in the criminal justice system*, The Royal Society, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4581008/pdf/rstb20140264.pdf.

[48]Chaudhery Mustansar Hussain, Technology in Forensic Science (2020), https://www.researchgate.net/publication/343963467_Technology_in_Forensic_Science.

[49] Verma, Ayush & Ramanathan, Krishnan, *Data privacy preservation in digital forensics investigation*, AIP Conference Proceedings (2022).

[50] Chaure, Suvarna & Mane, Vanita, *Digital Forensic Framework for Protecting Data Privacy during Investigation*, ICST Transactions on Scalable Information Systems (2023).

The intersection of scientific technology and forensic evidence holds immense potential for enhancing the Indian criminal justice system. However, addressing existing issues and carefully navigating the integration of AI are essential to realizing this potential. By adopting advanced technologies and ensuring rigorous legal and ethical standards, India can leverage forensic science to deliver justice more effectively and efficiently.[51]

Furthermore, forensic science in India suffers from a lack of public and governmental awareness regarding its importance. This often results in inadequate funding and political will to drive necessary reforms. Collaboration between law enforcement agencies, forensic laboratories, and academic institutions can help bridge these gaps. For instance, incorporating forensic science education into the curriculum of law enforcement training programs can enhance the understanding and appreciation of forensic evidence among police officers and judicial officials.

The ethical implications of forensic science practices also need attention. Ensuring that forensic procedures respect human rights and privacy is paramount. The misuse of forensic technologies, such as invasive surveillance methods, can lead to violations of individual freedoms and civil liberties. Thus, establishing clear ethical guidelines and oversight mechanisms is essential to prevent abuse.[52]

International collaboration and knowledge exchange can also play a crucial role in enhancing forensic practices in India. By partnering with leading forensic institutions globally, India can adopt best practices and innovative techniques that have proven effective elsewhere.[53] For example, the UK's Forensic Science Regulator provides guidelines and standards that ensure the quality and reliability of forensic services. Adopting similar standards in India, tailored to the local context, can significantly improve the reliability of forensic evidence. Additionally, international collaboration can facilitate the development of forensic databases, such as DNA databases, which can be invaluable in solving crimes that span multiple jurisdictions. By leveraging global expertise and resources, India can strengthen its forensic science capabilities and ensure that its criminal justice system is equipped to handle the challenges of the 21st century.[54]

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[51] *Ibid.*
[52] Sakshi Mehra, *Ethical dilemmas in Forensic Science- A curse upon India*, 4 (3) IJLMH Page 1297 - 1312 (2021), DOI: https://doij.org/10.10000/IJLMH.11406.
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 [ISSN 2581-5369]

## V. CONCLUSION AND SUGGESTIONS

The integration of advanced forensic technologies into the Indian legal system offers a promising avenue for enhancing the effectiveness and efficiency of criminal investigations. By adopting AI and other cutting-edge technologies, India can significantly improve the accuracy and reliability of forensic evidence, ultimately leading to more just outcomes. However, the transition to a more technologically driven forensic framework is fraught with challenges. These include the need for updated infrastructure, standardized practices, and continuous training for forensic professionals. Furthermore, the ethical implications of these technologies must be carefully considered to safeguard individual rights and prevent potential misuse.

To enhance the integration of forensic science into India's criminal justice system, it is crucial to implement comprehensive training programs for law enforcement and forensic professionals, equipping them with the skills necessary to leverage new technologies effectively. Developing robust legal frameworks with clear guidelines for the admissibility of forensic evidence, informed by international best practices, will ensure the reliability and integrity of evidence presented in court. Fostering international collaboration with leading global forensic institutions can facilitate the exchange of knowledge and adoption of innovative techniques tailored to India’s needs. Addressing ethical concerns through the development of guidelines and oversight mechanisms is essential to ensure the protection of human rights and privacy in the use of advanced forensic technologies. Additionally, raising public awareness about the importance of forensic science and securing adequate funding will be vital for driving necessary reforms and advancing the capabilities of India's forensic science infrastructure.

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 [ISSN 2581-5369]