A Succinct Analysis of Wildlife Conservation Law Enforcement through Forensic and Procedural Reforms in India

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Abstract. The human ecological security, health and climatic resilience are imperiled in today's era by rapid and adverse transformations in the eco environmental landscape world-wide. Despite having comprehensive legal frameworks for wildlife protection in India, defects in operationalization and suboptimal institutional responses have posed a threat to its pragmatic effectiveness. Thus, a due consideration to the conservation of the wildlife becomes sine qua non for the subsistence of entire mankind. Notably, the overabundance of legal frameworks without robust implementation has given rise to the peculiar enforceability issues. To that effect, institutional coordination in line with the prompt investigation and enforcement actions has become crucial. In parallel with this, forensic science has taken a giant leap in the recent times through direct integration under the New Criminal Law regime of India. Therefore, a cross-section of the legal regime regulating wild-life conservation, the quality of implementation of nor-mative structure and assessing the viability of forensic investigation within it would serve as an eye-opener and essential aid for the legislature and policy makers. This paper strives to alleviate the situation through identifying the 'enforcement deficit' and proposes the 'Strategic Forensic Procedural Blueprint' thereto. Ultimately, the paper summarizes the ways forward to secure regulatory strategies to conserve the wild-life, prevention of wild-life crimes through forensic expertise and procedural reforms.

Keywords: Wildlife, Poaching, Forensics, Crimes.

1 Introduction

"The wildlife and its habitat cannot speak, so we must and we will" [1].

India is a country particularly renowned for being rich and diverse in wildlife. Wildlife crime ranks as that third-largest illegal trade after narcotics and firearms, with serious

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consequences in ecological balance and biodiversity [2]. It's illicit trading is particularly rampant within states like Uttar Pradesh, Karnataka, West Bengal, Madhya Pradesh, Rajasthan and Assam which serve as some of the major transit routes [3]. The Wildlife (Protection) Act, 1972 provides strong legal as well as policy framework for the regulating and restricting wildlife trade and hence, prohibiting the trade of wild animals, plants etc. Although numerous agencies and legal bodies are working round the clock for the protection of wildlife, yet prosecutions for more than 70 % cases of wildlife crimes are not possible due to improper identification of species or the seized items [4]. Hence, crimes in wildlife are not an isolated issue of conservation in India, it is a properly organized criminal enterprise. As per the Wildlife Justice Commission Report of 2023, wildlife crime has been increasingly converging with other forms of organized crimes such as narcotics trafficking, money laundering etc. [5].

Under Section 9 of the Wildlife (Protection) Act, 1972, hunting, trading of sched-uled species and possession of wildlife articles is a crime. However, prohibition through legalities does not in itself ensure conviction. Courts need proof beyond a reasonable doubt to establish a crime. In wildlife crimes, however, this proof frequently collapses at the stage of species identification itself. Without molecular confirmation, the courts are unable to frame charges to sustain conviction and therefore, forensics in wildlife is a foundation of evidentiary sufficiency.

Against this backdrop, this paper conceptualizes 'wildlife crimes' as a distinct category of crimes while assessing its evolving nature through organized crimes, cross border trafficking and by examining those crimes which are perpetrated in the remotest areas and often go unreported. The paper also encapsulates the forensic perspective in investigation, collection of evidence and evaluates the various challenges faced by the law enforcement agencies. It scrutinizes the various loopholes in the procedures, failure of the deterrence value in the penal structure, weakness persisting in the institutional functioning and aims to overcome the same with nuanced Standard Operating Procedures that are forensically informed. In this regard, the empirical insights from the wild-life forensic experts were taken into account to assess the modalities of investigations [6].

The paper further adopts unique solution-based approach to re-evaluate the findings given by various judicial and administrative authorities in this regard. The lack of holistic approach to connect wild-life with current ecological apocalypse visible through irregular climatic situations across the planet has created a deep void in the policy frameworks.

2 Wildlife Forensics and Scientific Linkage

Wildlife forensic science is the analysis done to identify non-human biological material and add support to make prosecution stronger. It addresses the core investigative questions asked when trying to unravel a wildlife crime. The *TRACE Wildlife Forensics Network* explains that forensic analysis should be integrated with crime scene investigation, laboratory examinations and interpretation by the courts. Any weakness at these given stages would compromise the prosecution itself [7]. There are multiple forensic techniques of detecting wildlife crimes and identifying the evidences.

2.1 DNA Profiling and Species Identification

Mitochondrial DNA (mtDNA) profiling is highly effective while working on degrad-ed samples like bone, hair, ivory, horns etc. It helps in the identification of species and since it is it present in multiple copies per cell, it increases the success of recovery. Courts rely on this over morphological evidence. Morphological evidence is not precise, admissible and easily obscured and hence, courts cannot enforce this conventional evidence due to mixed samples, processed parts of animals and no molecular confirmation. DNA profiling in forensics helps in bridging this gap and removes ambiguity to strengthen judicial confidence.

DNA-based parentage analysis can assist investigators in determining whether an animal originated from the wild or from a captive breeding facility. In addition, species identification may be carried out through morphological examination of biological materials such as bones, hair, feathers, scales, and other tissues or organs. Such analyses are particularly important in wildlife crime investigations, as they help establish whether a specimen belongs to a legally protected species that may have been unlawfully taken. The factors giving impetus to the wildlife trade may not always be conclusive, nevertheless the global fashion trends, rare species and their marketing in medicines, cosmetics etc. have played pivotal role in sabotaging the wildlife kingdom in recent years. Its not gainsaying that, particularly endangered species cost more and can therefore be in higher demand by collectors due to higher profits compared to the risks and penalties incurred [8]. Microscopic examination and elemental analysis can also be applied to identify materials such as ivory and confirm their biological origin. Furthermore, pathological examination of carcasses, organs, tissues, and other biological samples obtained from deceased animals plays a crucial role in determining the cause and circumstances of death [9].

In the Gir Lion Poaching Case of 2007[10] Ten Asiatic lions were killed. DNA profiling was a critical step in confirming the identity of the species and linking all of the seized parts to carcasses. This case helped in demonstrating that wildlife forensics helps in establishing the particular species and individual matching of the animal, hence, turning suspicion into an admissible form of proof.

2.2 Ballistic Poaching and Forensics

Ballistics forensics in poaching cases, on the other hand, focuses on the examination of firearms. It studies angular movement, projectile dynamics concerning bullets, pellets, missiles gunpower and bombs. It plays a major role in criminal investigations in order to identify shreds of evidence that relates to powder burns, shell casings etc, associated with the usage of firearms and in detecting the residue left behind as evidence. It establishes 1) whether a firearm was used, 2) whether the recovered bullets match the weapons that were seized from the accused and, 3) the range and angle of firing.

2.3 Digital Forensics and Wildlife Trafficking

In wildlife crime, digital forensics too plays an important role in linking online or electronic activity with illegal wildlife trading. It refers to the collecting, preserving, analysing and presentation of digital evidence. A major question here is, how is it online? E-commerce platforms and social networks are increasingly being used to sell protected animals or their parts and hence, digital evidence can be used to support criminal investigations and prosecution, especially when no physical evidence or witness is present.

2.4 Morphological Analysis

This method involves the physical examination of animal parts such as bones, horns, skins, feathers, or teeth to determine the species. Experts compare seized wildlife products with reference collections to identify protected species under the Wildlife Protection Act, 1972.

Despite its potential, fingermark analysis remains an underutilized tool in investigating wildlife crimes. Compared to more commonly used methods like DNA analysis, it has not received the same level of attention, even though it is relatively inexpensive, easy to use, and can be applied directly in field conditions. Existing studies show that fingermark examination techniques have been successfully tested on a variety of wildlife-related materials, including pangolin scales, ivory products, bones, eggs, feathers, and animal skins items that are frequently trafficked in illegal wildlife trade [11].

2.5 Stable isotopes

Besides this, the isotope analysis for individual identification is relied upon [12]. The stable isotopes such as hydrogen, strontium, oxygen, carbon, nitrogen are found naturally within the environment and may vary across various regions and ecosystems. Animals have a tendency of absorbing these through water and their intake. These get incorporated into the tissues of these animals. Since these isotopes may differ

geographically, these tissues further act like the chemical fingerprint of whether the animal has lived in the surroundings where the dead animal is found. It can also provide the information about vegetation and food chain.

3 Wildlife Forensic Crime Scene Management

3.1 Identification of the Crime Scene

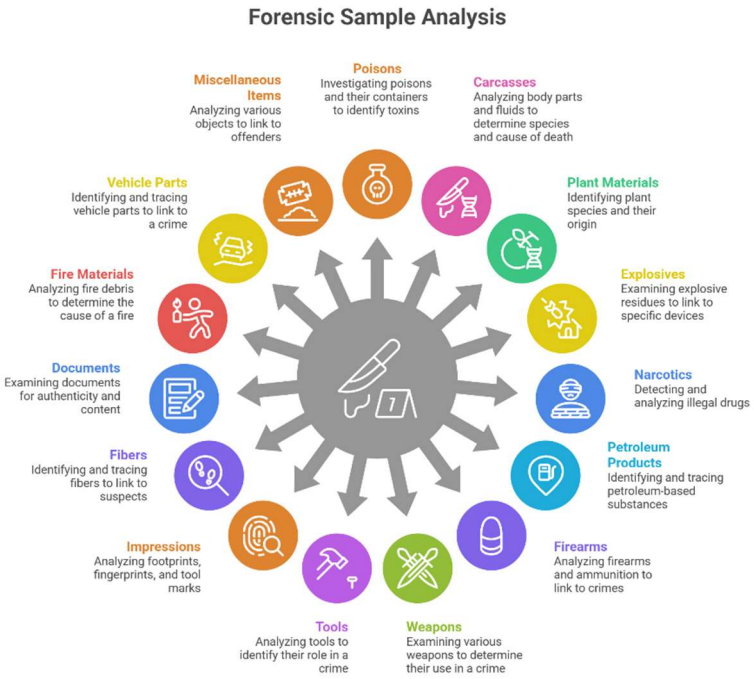
Unlike any other crime scene management, crimes scenes in the wildlife forensics requires more diligence and expertise right from the identification phase. Owing to the complex nature of the samples and influence of the weather and other atmospheric factors the identification becomes crucial for the investigators. To this effect, following intuitive chart would be a facilitating aid as to sampling identification and collection phase.

3.2 Forensic Sampling

The sampling entails multi-environmental facet. As states above, it involves biological, ecological and physical evidence which if not segregated properly, may not yield cogent reasoning. Therefore, forming a right approach before the investigation actually starts holds immense importance. It sets the tone for the evaluation and enables the investigation parties to priorities the collection procedure based on the 'need based approach'. A well-defined and documented crime-scene invariably contains the uninterrupted chain of custody. It also warrants and hence promotes the inter-cooperation between various sections of the FSLs.

In this regard, the following tabular figure explains various samples and its segregated into the national database.

Fig. 1. Classification of Forensic Samples in Wildlife Crime Scene Investigation
A visual representation created by authors



Such myriad samples require intricate detailing in collection and processing methods for their forensic analysis. A robust investigation and application of forensic expertise in it may eliminate the prospective question marks and allegations on the quality of the prosecution. The use of sterile tools and proper equipment can minimize the risk associated with tampering of evidences. The effective sampling primarily facilitates precise species identification and avoids erroneous reporting of cases. This can be further illustrated with the aid of following landmark case investigated in India.

4. The Blackbuck Poaching Case Study: Consequences of Inconclusive Forensic Evidence

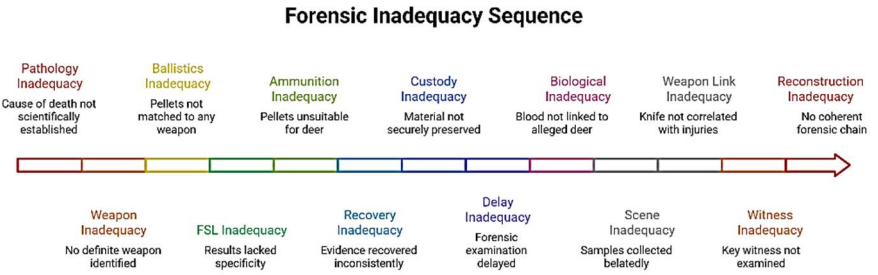
The The Blackbuck poaching case involving Salman Khan [13] shows how crucial forensic evidence is in wildlife crime cases. Although the allegation involved hunting a protected species under the Wildlife Protection Act, the prosecution could not firmly establish its case because the scientific evidence remained uncertain.

There was no clear medical or forensic basis to explain how the animal died or to connect the injuries to a specific weapon. The ballistic evidence also did not provide any definite answers, as the recovered pellets could not be reliably linked to the

accused. Along with this, gaps in recovery procedures and handling of evidence raised doubts about its reliability, particularly due to the absence of a clear chain of custody.

This case reflects a basic principle of criminal law that suspicion alone is not enough. Courts require clear and credible proof. When forensic evidence is weak or inconclusive, the benefit of doubt goes to the accused. It highlights that in wildlife crime prosecution, strong laws must be supported by equally strong and reliable forensic investigation as shown in figure 2.

Fig. 2. Visual presentation of the Salman Khan Case and Forensic Procedural Shortfalls



5. Institutional Mechanisms: The Wildlife Crime Control Bureau (WCCB)

In India, the Wildlife Crime Control Bureau (WCCB), was established under *Section 38(z)* of the WPA in order to serve as its central agency for wildlife crime intelligence. Some of its major functions involve the collection of wildlife offence related data, setting up a central offence data bank, proposing different actions and approaches for eradicating wildlife crime and prevent unlawful dealing and hunting of wildlife across the nation. Between 2018 and 2020, about 2054 wildlife crimes were registered in India [14].

The enforcement data given by *Wildlife Crime Control Bureau*[15] indicates that there is a notable shift towards investigations driven by intelligence, an increased coordination between agencies and a rise in detections of organized wildlife trafficking [16]. Another notable factor is the growing integration of forensic tools in investigations, specifically DNA profiling and species identification to strengthen evidentiary standards during court proceedings. This has therefore, enhanced prosecution success under the Wildlife (Protection) Act, 1972. This trend successfully demonstrates how wildlife forensics is gradually becoming central in order to secure convictions in wildlife crime cases in India.

Further, the Bureau, in collaboration with TRAFFIC, a leading NGO and WWF India, conducted a multi-agency training to enhance the knowledge and skills of

enforcement officers from state forest departments, customs, police etc [16]. *"Wildlife trafficking is not restricted to large animals alone but a whole lot of smaller and lesser -known species as well as plants. This affects the long-term conservation of the species and habitats". "Trafficking of exotic wildlife species is also a growing concern now as in case of release of exotic wildlife in non-native habitats it can become invasive threat ening the native population and habitats"* [17].

Dr. Malay Shukla, Wildlife Forensic Expert, National Forensic Sciences University opined that various cases ranging from illegal hunting, illegal wildlife trade and trafficking, capture of live animals, bushmeat hunting, trophy poaching for trophies such as skins, heads, horns, or antlers, illegal collection of wildlife products and poisoning are the types of cases that are forwarded for forensic analysis. Current forensic techniques involve tracing the morphological features through microscopic analysis (external and internal), mineral deposition, radiological DNA analysis, DNA sequencing and comparing the acquired sample with the data available in National Centre for Biological Sciences, Bengaluru.

Dr. Shukla also stated that currently every laboratory follows its inherent SOP and there is need for developing a uniform SOP across the country outlining the role of forensics in crime detection and conviction. He also further opined that drafting the uniform SOP and maintaining the records, search history and investigation reports can further aid in solving the similar cases. A database of the species usually found in the respective geographical regions and a reference depository should be established. He gave an example of the National Centre for Biological Sciences, Bengaluru while explaining the significance of maintaining the data. Such databases can assist in comparing and bridging the gaps in investigation.

6. Procedural Gaps and Challenges in Structure

Despite significant progress, many challenges still persist in the procedure and structure of Wildlife law. Section 50 of the WPA provides a right to search and seizure, however, it does not prescribe codified forensic sampling protocols. There is no mention of a time-bound forensic collection, documentation of the chain of custody or standardized labelling and sealing of the collected evidence. This might lead to procedural vulnerability. The Blackbuck Poaching Case (1998) exposed how inconsistency in keeping seizure records generate judicial suspicious that leads to courts disregarding evidence due to doubtful custody integrity. Apart from this, enforcement mechanisms still remain physical-evidence focused up to date despite the increase of digital trafficking which leads to an enforcement lag.

Since forensic sampling is not standardized, it leads to acquittals and contamination of evidence. A significant reform would be to codify collection rules under the WPA. To avoid judicial distrust, the chain of custody should be strengthened and digital tracking of the evidence transfers should become mandatory. To further weaken the

expansion of organized crime, WCCB should dedicate a special forensic unit within itself for cyber-wildlife crimes.

7. Comparative Analysis

In India, substantive prohibitions are provided by the Wildlife (Protection) Act, 1972, however, it lacks procedural forensic mandates that lead to an insufficiency in evidence as seen in the case cited above. A structural shift came into place with the introduction of the Bharatiya Nagarik Suraksha Sanhita, *Section 176(3*) which makes forensic expert visits mandatory and for further serious offences, videography of the crime scene. Sections 329-330 further streamline the admissibility of forensic and scientific reports which thus, reduces procedural issues and contestations. This trajectory is reinforced by a comparative analysis with South Africa's *Rhino DNA Index System* (RhODIS)[18]. It was developed under enforcement frameworks of biodiversity in the country, such as, the National Environmental Management Biodiversity Act. This enabled a linkage of the species to its carcass through DNA profiling and significantly helped in improving the rates of conviction in rhino poaching case.

A well-known international case demonstrating the importance of forensic science in combating illegal wildlife trade is United States v. Zhifei Li [19]. In this case, Zhifei Li, a Chinese national, was convicted in the United States for trafficking rhinoceros horns and ivory worth millions of dollars. The investigation involved cooperation between the United States Fish and Wildlife Service and international enforcement agencies. Wildlife forensic experts conducted DNA and morphological analyses on seized ivory and rhinoceros horn products to determine the species and confirm that they originated from protected animals listed under international conservation laws. The forensic examination helped establish that the items were illegally sourced and trafficked across international borders. The scientific evidence presented by experts played a crucial role in linking the accused to the illegal trade network and securing his conviction. This case illustrates how wildlife forensic techniques such as DNA identification and species verification are essential tools in detecting and prosecuting transnational wildlife trafficking.

Similarly, Australia also integrated molecular forensics and digital forensics and investigation into their wildlife crime prosecutions under the Environment Protection and Biodiversity Conservation Act. This can be illustrated with the tabular representation of the data given below in table 1.

Table 1: Tabular Representation for Comparison

Country	Key Institution	Major capabilities

United States	Clark R. Bavin National Fish and Wildlife Forensic Laboratory- supports investigations under Convention on International Trade in Endangered Species (CITES). (U.S. Fish and Wildlife Service, n.d.) [20]	DNA analysis, species identification, ivory analysis, hair and feather examination
United Kingdom	TRACE Wildlife Forensics Network and laboratories- develops forensic tools and supports governments in applying forensic science. (TRACE Wildlife Forensics Network (n.d.)) [21]	Wildlife DNA analysis, illegal trade identification, forensic training
Australia	Australian Centre for Wildlife Genomics and university forensic laboratories- integrates wildlife forensic research with universities and museums to identify illegal wildlife trade and protect biodiversity**. (**Australian Centre for Wildlife Genomics (n.d.)) [22]	DNA barcoding, genetic identification, species authentication
Canada	Alberta Fish and Wildlife Forensic Unit- Specialized forensic units assist law enforcement in investigating illegal hunting, trade, and habitat crimes. (Alberta Fish and Wildlife Enforcement Branch (n.d.)) [23]	Genetic identification, species verification, wildlife crime investigations
African Region (Botswana, Zambia, Uganda etc.)	African Wildlife Forensics Network- Regional network supporting forensic capacity, training, and	Wildlife DNA analysis, crime scene investigation, laboratory collaboration

	access to wildlife forensic services across Africa. (African Wildlife Forensics Network (n.d.)) [24]	

8. Findings

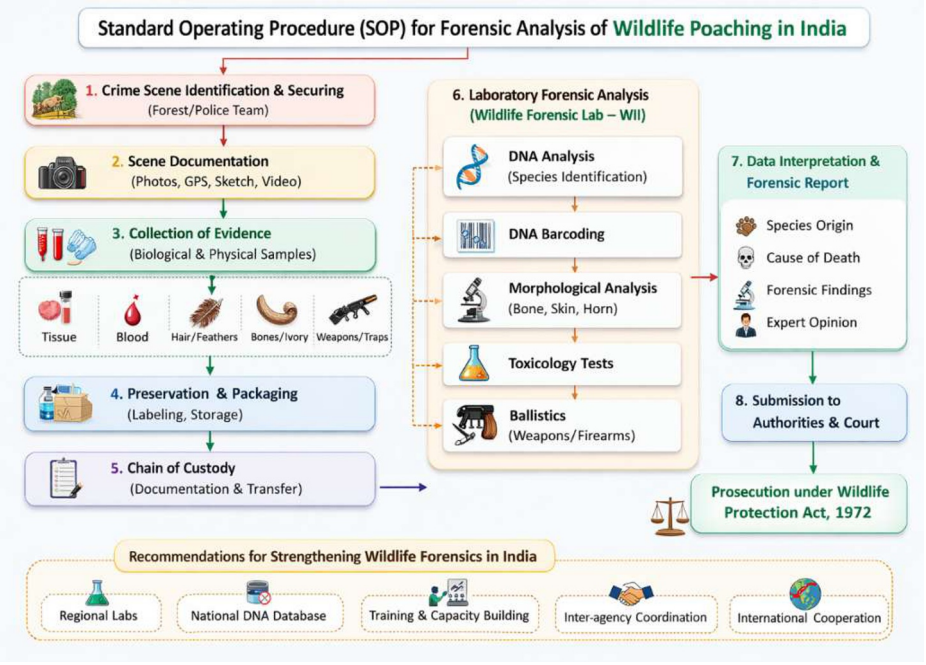
The increasing incidence of wildlife poaching and illegal wildlife trade has made it essential to develop a standardized Standard Operating Procedure (SOP) for the forensic analysis of species involved in wildlife crimes. Wildlife investigations often involve the examination of biological materials such as tissue, bones, hair, feathers, horns, or ivory, which require precise scientific handling and analysis. In the absence of a uniform protocol, inconsistencies in the collection, preservation, and examination of samples may compromise the integrity and reliability of forensic evidence. A well-defined SOP ensures that investigators follow a systematic process for crime scene management, evidence collection, chain of custody, laboratory analysis, and reporting. Such standardization is crucial for maintaining the evidentiary value of scientific findings and ensuring their admissibility before courts under the Bharatiya Sakshya Adhiniyam, 2023. The challenges nevertheless continue to exist due to lack of appropriate standardization, increased institutional burden and lack of cooperation from allied investigative authorities. Another issue of transnational wildlife crimes and the detection of these crimes through proper channel is necessary given the growth in sophistication of methods of illegal trade and poaching. International cooperation has a pivotal role in combating these crimes through appropriate implementation of international laws and adhering to the international conventions. Drafting of uniform policies across the nations, training the personnel for collection of vital evidences and garnering support from locals when required could reinforce the sustainable conservation.

Wildlife forensic investigations in India face several structural, technical, and institutional challenges that hinder their effectiveness in combating wildlife crime. One of the primary issues is the limited number of specialized wildlife forensic laboratories capable of conducting advanced analyses such as DNA profiling, species identification, and toxicological examinations. Although institutions such as the Wildlife Institute of India have developed significant expertise in wildlife forensics, the overall forensic infrastructure in the country remains insufficient to handle the growing number of wildlife crime cases. Additionally, there is often a lack of standardized protocols for crime scene investigation, evidence collection, and preservation, which can compromise the integrity of biological samples and weaken their evidentiary value. Another challenge is the lack of training and awareness among field-level enforcement officers, including forest officials and police personnel, regarding proper forensic

procedures and chain-of-custody requirements. Delays in laboratory analysis, inadequate coordination between investigative agencies, and the absence of a comprehensive national wildlife DNA database further limit the ability of authorities to accurately identify species and trace the origin of seized wildlife products. These issues ultimately affect the effective prosecution of offences under the Wildlife Protection Act, 1972, highlighting the urgent need to strengthen wildlife forensic infrastructure and institutional capacity in India.

To support law enforcement efforts in protecting endangered wildlife, a range of scientific techniques are increasingly being used to collect and analyze wildlife crime data. These include tools such as artificial intelligence, statistical analysis, computational modelling, genetic testing, chemical examination, and geographical mapping. By combining these approaches, investigators are better equipped to generate actionable insights that can directly aid in detecting, investigating, and preventing wildlife-related offences as shown in figure 3 [25].

Fig. 3: Created by the Authors depicting SOPs for Forensic Analysis of Wildlife Poaching in India



Thus, these steps include crime scene identification and securing followed by preservation and packaging. The relevant evidence should be located, collected, and

properly packaged using standardized procedures to maintain its condition. The chain of custody is essential for preventing contamination or situations of substitution. Maintaining proper chain of custody assures transparency thereby enhancing the quality of evidence for the prosecution. Further the Laboratory anaylsis for performance of tests and interpretation of reports marks an important step. There should however be an assistance and assessment of reports submitted to the judiciary for weighing the scientific evidences submitted to the court.

9. Conclusion

The statutory prohibition of hunting, trading and possession of protected species under the Wildlife (Protection) Act, 1972, without evidentiary sufficiency is merely symbolic. Through this paper, it has been demonstrated that, DNA profiling helps in identification of species and leads to judicially reliable proof. Ballistic forensics further eliminates speculative defenses and strengthens prosecution. In brief, if one considers the definition agreed upon by the Society for Wildlife Forensic Science (SWFS), that wildlife forensic science is the application of a range of scientific disciplines to legal cases involving non-human biological evidence [25]. Judicial cases highlight that convictions hinge significantly upon scientific proof and coherence. In the absence of the same, prosecutions collapse at the framing of charges, but, with it, the courts are empowered to convict the accused beyond a reasonable doubt. The role of forensic experts in gathering evidences should assume a preventive role considering the contributions in the trial against perpetrators. An interdisciplinary approach among the conservation biologists and law enforcement agencies poses a potential for having cohesive response to wildlife crime.

This capacity to derive a significant probative value from the insignificant biological remnants transforms seemingly untraceable offences into prosecutable cases. Therefore, wildlife forensic science acts as the bridge between criminal accountability and the protection policy. Integration of emerging technologies such as the big data analytics can assist in revolutionizing the forensic wildlife investigations. Each trace that is discovered through forensic investigation is not merely evidence of crime, but a reminder of our shared responsibility of protecting all the species.

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