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ANALYSIS OF ROLE OF FORENSIC SCIENCE IN COMBATING ILLEGAL POACHING AND TRADE

Dr. Ashima Jain[1]

Abstract: *The escalating threat of poaching and illegal trade in wildlife internationally has its roots in social inequalities, organized crime, and demand from consumers. The poaching and trafficking of wildlife endanger species and facilitate greater biodiversity loss aggravated by habitat destruction and environmental degradation. With many species hanging by a thread, we desperately need effective tools for investigation in wildlife crime. Forensics, especially advances in forensic genetics like DNA profiling and stable isotope analysis, are of great importance in the investigation of wildlife crimes. These give the capacity for authorities to trace the origin of seized wildlife products, identify poached animals, and connect offenders with these crimes, thereby strengthening the legal case and resulting in successful prosecution. This article reviews the development and utilization of forensic techniques for wildlife crimes, how scientific evidence has undermined international trafficking networks, and notable case studies that show how these innovations have been put into enforcement strategies for justice. These efforts support the goals set forth by the United Nations. It aids biodiversity conservation (SDG 15-Life on Land); enhances legal enforcement (SDG 16-Peace, Justice, and Strong Institutions); and discourages illegal exploitation of wildlife (SDG 12-Responsible Consumption and Production). The intersection of forensic science with conservation and law enforcement activities serves the dual purpose of combating wildlife crime and advancing pillars of global mark on sustainability, environmental justice, and the protection of vulnerable ecosystems.*

Keywords: *Wildlife; crime; court; evidence; DNA. SDG 15*

INTRODUCTION

Wildlife poaching and the illegal trade in its parts are a direct contravention of environmental and conservation codes, and they testify to an ethical malaise within our civilization-viewing such crimes against nature as a means of accelerating the cause of ecological balance and sustainable development.

Poaching involves the unlawful hunting, capturing, or killing of wild animals in direct defiance of national as well as international laws on conservation of biodiversity. Today's poaching is born out of colonial mentality-hence practiced for ulterior motives-by well-organized cartels acting as opposite forces to the interest of transnational organized crimes that jeopardizes the existence of rare animals when gripped by local conflicts, financing even radical terrorist organizations. Illegal wildlife trade (IWT) is said to earn about $7 to $23 billion a year-while it is a highly lucrative enterprise, it is relatively low-risk in terms of detection and punishment. Law enforcement to check this is almost ineffectual in that the penal laws in the respective countries are incapable of acting as a deterrent, plus it does not track the wide scale of smuggling.

That is why the international community should urgently recognize the IWT crisis as a crucial menace to crying out for the protection of biodiversity but also as an immediate threat to global peace and ethical governance and economic stability. This acknowledgment becomes even more urgent for wildlife-rich but poorer nations as illegal sourcing of wildlife parts from the origins-the very wildlife-poaching-for export to markets globally, also wants products for exotic pets, ingredients for traditional medicines, luxury items, and bushmeat[1].

The whole complex of supply works through consortiums and networks-poachers on the ground, intermediaries moving goods, traffickers and international smugglers moving the large-scale shipments, and the end consumer creating demand. The price exacted on some of the charismatic species, such as elephants, rhinos, tigers, and pangolins, is devastating-those whose body parts fetch equally high prices in illegal markets are pushed toward extinction. Unless a tightly coordinated international legislative response is passed, coupled with very strong law enforcement efforts and inclusive policy frameworks to address wildlife trade (IWT), IWT will not only destroy ecosystems

[1] Assistant Professor, School of Law, Manipal University Jaipur, Rajasthan, India.

[1] Smart U, Cihlar JC and Budowle B, 'International Wildlife Trafficking: A Perspective on the Challenges and Potential Forensic Genetics Solutions' (2021) 54 Forensic Science International: Genetics 102551

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in its current path, hampering progress toward Sustainable Development Goal 15: Life on Land that aims to combat the extinction of biodiversity, but also threatens SDG 13: Climate Action by weakening further ecosystems and local economies that depend on them since the destruction of ecosystem functions weakens carbon sinks and increases the vulnerability of the biosphere. It's a dire scenario. The number of wild tigers worldwide is probably down to about 2,000-3,000. Between 1993 and 2014, the African lion population plummeted by 43%. White rhinoceroses were reported to be fewer than 21,000 in 2012 but more than 18,000 by 2017. The conservation hotspots, including Kruger National Park in South Africa, have witnessed poaching with an alarming increase since 2011, which alone has contributed to a 67% decline in population of white rhinos, while their African forest counterparts saw a very disturbing 80% decline over their natural range in distribution during that time[2].

This human impact is gradually leading to the loss of biodiversity. The World Wildlife Seizure (World WISE) database managed by the UN Office on Drugs and Crime records over 180,000 seizures in 149 countries, with involvement of more than 6,000 species. Much of this information is drawn from reports under the Convention on International Trade in Endangered Species (CITES), showing worldwide trafficking practices and the extent to which the trafficking networks are spread across the globe[3].

Biodiversity crisis intersects quite deeply with the SDGs, accentuating the need for systemic reforms. Stronger legal enforcement, higher financial investment for conservation, and elevated levels of global awareness are needed for the attainment of SDG 16, which denotes Peace, Justice and Strong Institutions-for crime and illicit financial flows reduction. Likewise, SDG 12 emphasizes Responsible Consumption and Production, which denotes sustainable use of natural resources. After all, biodiversity conservation is needed for ecosystem resilience and stability of human societies. Not acting now will lead to irreversible ecological damage, loss of species, and the destruction of the natural systems that uphold life on Earth. A concerted global approach engaging all stakeholders that reconciles legal, social, and economic with environmental perspectives must forge the way of fighting against illegal wildlife trade and sustaining life on this planet for posterity[4].

POACHING

Corruption underlies most of everything poaching and illegal wildlife trade entail, and most importantly, self-interest in deep-seated context along with other aggravated systemic socio-economic conditions enable this behavior further. Principal of corruption among enforcement agencies and conservation bodies are primarily associated with very poor compensations towards their organizational officials. Bad salaries expose them to much more bribery and collusion with organized crime syndicates engaged in organized illicit wildlife trafficking. Thus, such officials collude in the weakening of enforcement structures, paving the way for unhampered poaching activities[5].

Macro, general socioeconomic adversities like poverty, almost displacing indigenous people from their protection areas, and exclusion from the resource management are important factors that perpetuate poaching. The forced eviction of indigenous or local communities from their customary lands-in the name of conservation-erects socio-political tensions between these people and political elites who accrue wealth from enclosures of land and wildlife resources. Marginalized and alienated, such communities face coiled lacerations caused by the conflict of humans with wildlife, destruction of crops, and lack of livelihood support, subject to their exposure above. Such situations often tolerate poaching as a means of survival and not a crime. This aligns with SDG 1 (No Poverty) and SDG 15 (Life on Land) and addresses immediate action through the establishment of community-driven conservation programs for equitable benefit-sharing, participatory land

[2] Hinsley A and others, 'Early Warning of Trends in Commercial Wildlife Trade through Novel Machine-Learning Analysis of Patent Filing' (2024) 15 Nature Communications

[3] Peter Coals et al., *Preferences for lion and tiger bone wines amongst the urban public in China and Vietnam*, 57 Journal for Nature Conservation, 125874 (2020)

[4] ((PDF) African and Asian rhinoceroses-status, conservation and trade a report from the IUCN Species Survival Commission (IUCN SSC) African and Asian Rhino Specialist Groups and traffic to the CITES secretariat pursuant to Resolution Conf. 9.14 (rev. COP15)) <https://www.researchgate.net/publication/331988560_African_and_Asian_RhinocerosesStatus_Conservation_and_Trade_A_report_from_the_IUCN_Species_Survival_Commission_IUCN_SSC_African_and_Asian_Rhino_Specialist_Groups_and_TRAFFIC_to_the_CITES_Secretariat_> accessed 13 April 2025

[5] Secretariat pursuant to Resolution Conf. 9.14 (Rev. CoP17). Rep., IUCN SSC Afr. Rhino Spec. Group, IUCN SSC Asian Rhino Spec. Group (AsRSG), TRAFFIC, Cambridge, UK Stoddard E. Rhino poaching rebounds from Covid-19 containment—private reserves fight a surge; 2021

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management, and inclusive governance. When communities are empowered and thus included directly in conservation efforts, the protection of biodiversity works in their socio-economic interests; therefore, illegal activities become less likely[6].

Also showed the inadequate stature of both the manpower and technological resources of enforcement agencies that have failed to identify, monitor, and disrupt poaching networks. Nonavailability of latest scientific tools like ecological forensics, satellite tracking, and DNA analysis, coupled with obsolete legal frameworks and thin deterrents, adds much confusion to wildlife crime enforcement process. In this regard, SDG 16: Peace, Justice, and Strong Institutions indicate the necessity of strong institutional frameworks and legal deterrents with trained manpower that can effectively bring down such criminal networks[7].

From a sociocultural perspective, the consumption of wildlife products among people is embedded in traditions for ages, particularly in parts of Asia. In countries such as China, the possession and consumption of such products as rhino horns, ivory, pangolin scales, and tiger bones often has as associates wealth, power, and prestige in society. Among the affluent classes—particularly upwardly mobile young professionals—this is likely to symbolize elite status, partaking in ceremonies, gifting, and personal adornment. Cultural beliefs are so entrenched that consumers find it incredibly challenging to change their behavior. Thus, while laws and awareness campaigns might be helpful, they are still insufficient against entrenched social norms and economic incentives.

The unending demand for rare wildlife products has high pressure on already endangered species and pushes them closer to extinction. This demand, unchecked, runs counter to the objectives of SDG 12 (Responsible Consumption and Production) and SDG 15, which together talk about resource use sustainability and biodiversity conservation. It should be through education, outreach campaigns that will culturally sensitive, and strategic policy interventions to bring about change in behavior for demand mitigation and consumption reduction[8].

Illegal wildlife trade takes many exploitative forms: bushmeat markets, exotic pet trades, fashion industry interests in animal hides and feathers, and any part of an animal used in a traditional medicine system. Traditional Chinese medicine (TCM) has continued to thrive as it has used animal products such as bear bile, rhino horn powder, pangolin scales, and bone-infused tonics for more than 2000 years of practice. Thus, the use of these animal-based remedies is well marketed in modern medicine where most are viewed as a cure for ailments ranging from common colds to reproductive complexity. This brings in great addition to poached wildlife and can disrupt the conservation efforts.

An approach requires a road to sustainable progress at multiple levels. This sounds fine; however, the next level needs complemented law enforcement with public education initiatives, scientific research and monitoring systems, and community engagement strategies. The laws must include both national and international collaboration such as CITES (Convention on International Trade in Endangered Species) for framing and implementing limits on wildlife trade.

Some have proposed these breeding programs and regulated harvesting as a market-oriented alternative to combating the demand for illegally procured items. The premise is that while legally sourced wildlife goods, such as tiger bones or lion bones, are available from farmed animals, poaching would be discouraged, and prices would stabilize or decrease. This modality has thus far been applied in South Africa and other countries in Asia, where captive breeding programs for lions have caused an increase in their populations in captivity but, at the same time, a decrease in wild populations due to habitat-induced threats and poaching[9].

However, these programs have been highly controversial. In South Africa, lion bones initially considered a secondary by-product of trophy hunting soon became the primary

[6] Carnie T, 'Rhino Bloodbath in KZN as Poachers Gun down 75 Animals This Year Rhino Bloodbath in KZN as Poachers Gun down 75 Animals This Year' (*Daily Maverick*, 5 April 2022) <https://www.dailymaverick.co.za/article/2022-04-05-rhino-bloodbath-in-kzn-as-poachers-gun-down-75-animals-this-year/> accessed 13 April 2025

[7] Rademeyer J, 'An Unwinnable War: Rhino Poaching in the Kruger' [2017] Militarised Responses to Transnational Organised Crime 43

[8] 'Loxodonta Cyclotis: Gobush, K.S., Edwards, C.T.T, Maisels, F., Wittemyer, G., Balfour, D. & Taylor, R.D.' [2020] IUCN Red List of Threatened Species

[9] Gregory R, 'Faculty Opinions Recommendation of WWF (2020) Living Planet Report 2020 - Bending the Curve of Biodiversity Loss.' [2020] Faculty Opinions – Post-Publication Peer Review of the Biomedical Literature

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product for trade. Between 2013 and 2016, the annual export of lion skeletons surged from a few hundred to over 1,700. With that, CITES imposed an annual export quota, recognizing the potential for abuse and injurious ecological consequences. A major policy shift followed when the government of South Africa banned captive lion breeding and ceased issuing permits for lion bone exportation.

While such decisions signal progress, they go deeper into establishing the competing moral views surrounding wildlife farming for commercial gain. Critics argue that legitimizing wildlife trade, even from legal sources, fosters demand and hampers enforcement against illegal actors. Proponents, on the flip side, consider it to be a trade-off between economic incentives and conservation goals. Every decision taken along this line must squarely respond to SDG 12 and SDG 15 for long-term ecological sustainability and moral obligation.

Thus, poaching being not only an environmental or legal issue poses a difficult socio-economic, cultural, and governance challenge that must find alignment with wider sustainable development pursuits. Addressing the underlying causes of wildlife protection, i.e. poverty, exclusion, corruption, lack of enforcement, and consumer demand from the SDG perspective, will reap a more holistic and effective approach. Only through integrated means of conservation science, social equity, cultural reformation, and legal enforcement can the extinction of endangered species be guaranteed, as well as the health of ecosystems for generations to come[10].

FORENSIC EVIDENCE IN ANIMAL CASEWORK

DNA analysis has drawn great attention as a core and indispensable technique for fieldwork and conservation-oriented forensic investigations in wildlife. Recently, it has offered reliable alternatives when biological materials, such as hair, skin, bones, and tissues, are degraded or transformed because of decomposition, environmental exposure, or human handling, rendering them impossible for morphological identification. It revolutionized the field and remains the leading method of scientifically accepted evidence in civil and criminal courts to date, having been discovered over forty years ago. It is increasingly applicable to wildlife crime, thus serving as a key pillar in prosecuting offenses related to illegal poaching and trafficking of endangered species and other biodiversity-related transgressions.

The advancement of forensic techniques in wildlife investigation has run parallel to developments in human forensic science. In contrast, special laboratories adopt specific protocols suited to each unique complication arising from non-human species. Such laboratories typically face unique challenges, for example, limited databases for reference, diversity of species, and a need for non-invasive sampling techniques, which demand development. For example, forensic scientists can now retrieve viable DNA from very small or not-so-good samples and provide identification of species, geographic origin, and possibly even individual animals in some cases. This ability is crucial in the fight against complex and transnational wildlife crime[11].

Wildlife crime scenes often contain a variety of biological traces, including but not limited to blood stains, tissue fragments, bones, feathers, and excreta. These specimens would be collected and preserved through the efforts of a trained team under field conditions for later analysis in the lab. However, with increasing complexity of wildlife crimes, including the illegal wildlife trade through online businesses, and changing methodologies of smuggling, forensic laboratories have to constantly upgrade their analytical methods to keep ahead of the offenders. Building capacity continuously, interdepartmental coordination and dovetailing of modern molecular means will ensure both the scientific reliability and the legal admissibility of wildlife forensic evidence.

In working towards achieving the Sustainable Development Goals (SDGs), wildlife forensics becomes vital in assessing global initiatives for environmental sustainability and the rule of law. More specifically:

- For SDG 15, Life on Land, the protection, restoration, and promotion of sustainable use of terrestrial ecosystems, halting the loss of biodiversity, and combating poaching and trafficking of protected species. Forensic DNA tools identify trafficked animals and trace their origins to assist in enforcing biodiversity conservation, thereby assisting enforcement agencies and conservationists.
- SDG 13: Climate Action is supported indirectly, as wildlife protection helps in maintaining ecological balance and resilience to

[10] (*TNRC introductory overview corrupting trade: An overview of corruption issues in illicit wildlife trade | WWF*) <https://www.worldwildlife.org/pages/tnrc-introductory-overview-corrupting-trade-an-overview-of-corruption-issues-in-illicit-wildlife-trade> accessed 13 April 2025

[11] *Ibid*

climate change. Healthy biodiversity protects against climate change through carbon sequestration, water regulation, and disaster mitigation.

- SDG 16 is reinforced by the establishment of science-based legal processes that ensure the prosecution of wildlife crimes. Enhanced capacity in forensic science would lend credibility to judicial processes and aid those states in enforcing environmental justice.

The further development and enforcement of forensic investigation techniques in wildlife protection will bridge science and justice. In aiding the accurate identification and prosecution of wildlife crimes, these techniques will further contribute not only to the enforcement of national and international laws for conservation but towards sustainable development in general. The very existence of forensics in wildlife law enforcement will become increasingly relevant in nurturing the prospects of an integrated approach that embodies human progress and ecological preservation, witnessing increasing threats to biodiversity from illegal exploitation[12].

CRIME SCENE EXAMINATION AND SAMPLING

Investigative approaches being used to tackle the illegal wildlife trade vary across jurisdictions due to geographical characteristics and the capacity of enforcement authorities within them. The complexity of such nature of investigations stem from the fact that the investigation involves a wide variety of species and very different types of evidence found remote crime locations necessitating specialized training and techniques in such investigations. Forensic capacity development is thus extra important for jurisdictions looking into enhancing the ability of the courts to effectively prosecute against wildlife crimes[13].

A landmark case in wildlife law enforcement using forensic science comes from the Eastern Cape of South Africa. Conviction of a well-known rhino poaching syndicate depended upon the forensic analysis of bloodstained saws belonging to a rhino named Campbell, which had been killed in 2016 in a private estate: DNA matching, cell phone tracking of calls made to the poacher operator while surveilling rhinos, and ballistic analysis of dart guns for cross-examination of witnesses were very convincing measures that were collected. The identification of yellow paint chips found at the crime scene and matched chemically and physically to the saw's paint layers further ruled out other sources. Some moral weight was added to the prosecution through veterinary testimony about the brutal nature of rhino poaching, bringing insight into the suffering experienced by these animals.

This shows that while there are many advancements in forensic science, there is still very much dependent effectiveness related to strong legal framing governing wildlife protection. Comprehensive laws, well-defined policies, and specialized judicial processes are critical for combating poaching and illegal trafficking. Establishing trained and knowledgeable legal practitioners from experts such as prosecutors and magistrates will enhance interpretation and presentation of scientific evidence in court. Setting up specialized wildlife courts in high incidence regions would enhance judicial responsiveness and efficiency.

Another factor making a contribution to the enhancement of wildlife forensic methods is the realistic use of these methods in the field. All the contributions of forensic science developed by or for humans need to be adapted and validated for applications in wildlife. This is going to take research, forensic practice, conservationists and law enforcement agencies working together. For instance, fingerprinting methods - such as gelatin lifters - have been redesigned to retrieve prints from trafficked pangolin scales. However, each of these innovations must be shown through rigorous testing to withstand the rigors of environmental conditions and legal systems in the country where they are intended for use.

Holistic and integrated approach is needed for successful investigations in wildlife crime. This means considering combatting climate, forensic infrastructure, procedural standards, and administrative responsibility while implementing forensic strategy. Ultimately, this whole venture into illegal wildlife trade is going to be one involving relentless innovations, cross-disciplinary collaboration and committed

[12] Haines AM, Webb SL and Wallace JR, 'Conservation Forensics: The Intersection of Wildlife Crime, Forensics, and Conservation' [2021] Wildlife Biodiversity Conservation 125

[13] Richards NL and others, 'The Role of Conservation Dog Detection and Ecological Monitoring in Supporting Environmental Forensics and Enforcement Initiatives' [2021] Wildlife Biodiversity Conservation 287

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investment in conservation and legal enforcement[14].

ANIMAL DNA EVIDENCE IN LEGAL PROCEEDINGS

The rare or common statistical occurrence of a genetic profile in a specified population needs to be very clearly expressed such that the reliability of the match is firmly supported. This form of contextualization serves to enhance the probative force of forensic testimony and goes a long way in averting misinterpretation[15].

The admissibility of expert evidence is still bound by the law of the jurisdiction in which it is led, regardless of its implications in human or animal forensics. Therefore, forensic practitioners must understand the relevant legal requirements, regulations, and landmark court rulings that pertain to their area. The Daubert and Frye standards are the two major methodologies in the United States directed towards the scientific validity and legal relevance of expert testimony. As forensic science, particularly DNA analysis, evolves, this is the time to constantly revise legal standards and guidelines to integrate emerging methodologies and remedy any weaknesses exposed during court review.

Accurate species identification is the foundation of prosecuting wildlife crimes, especially for illegal trades in species controlled by CITES and national legislation. Misidentified species have accounted for a large number of failed or dismissed wildlife crime cases, with an estimate of over one-third of such prosecutions being affected. An accurate identification may have determined the severity of the punishment furthermore, it also gives an indication of the threat level the species is subjected to, which would contribute to drafting conservation measures.

While not strictly cases of wildlife poaching, several incidents involving domestic animals have created loopholes in wildlife forensic science. The introduction of domestic case law has exposed the inadequacies faced in evidentiary validation and established the need for a system of standard forensic methods. For instance, in the early cases of animal forensic investigations involving domestic cats, the establishment of species population databases and standard testing methods gained recognition. Such precedence would strengthen forensic processes and further civil and criminal aims in the better prosecution of wildlife crimes[16].

Another notable improvement in forensic science is the increasing importance of pet animal hair, especially from domestic animals, as trace evidence in criminal investigations. Hair can easily stick to clothing and transfer between people and crime scenes, providing important forensic links. A landmark case illustrated the advantage of STR genotyping in analysing animal hair and set a precedent for its application onwards in forensic investigations. This case also emphasized the necessity for validated STR tests and the establishment of large species-specific DNA databases[17].

In circumstances where the only material left for examination is shed hair, mitochondrial DNA (mtDNA) becomes important when nuclear DNA is insufficient for STR analysis. An important instance would be the State of Missouri v. Henry L. Polk, Jr., where a single cat hair found on the victim's clothing was subjected to control region mtDNA sequencing. In spite of the inability to extract nuclear DNA, evidence on the basis of mtDNA became central to the first-degree murder conviction in that case. The case emphasizes that mtDNA analysis becomes especially valuable under conditions when conventional DNA profiling would not work, and it further indicates that establishing DNA databases may aid considerably in presenting forensic evidence in the court. While there are no established standards currently on what would constitute an ideal size of forensic DNA databases, the Missouri case indicates that even small datasets can affect tremendously in their legal implications. Larger, more inclusive databases will assist in further refining and strengthening the reliability of forensic DNA matchwork and, in turn, assist the justice system in dealing with some of the increasingly complex biological evidence[18].

[14] Jabin G and others, 'DNA Forensics in Combating Illegal Wildlife Trade: Present, Past, and Future Perspectives' [2020] Forensic DNA Typing: Principles, Applications and Advancements 399

[15] Kashyap D and others, 'A Comparative Microscopic and Micrometric Analysis of Birds of Different Feather Types for Identification of Species' (2024) 27 Journal of International Wildlife Law & Policy 235

[16] Kotze A and others, 'Understanding Illegal Trade in Pangolins through Forensics: Applications in Law Enforcement' [2020] Pangolins 321

[17] Manqana MM and others, 'Exploring the Techniques and Challenges for Recovering Human Touch DNA from White Rhino (Ceratotherium Simum) to Combat Poaching' (2025) 369 Forensic Science International 112417

[18] Burnham-Curtis MK and others, 'Wildlife Forensic Genetics and Biodiversity Conservation: The Intersection

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CASE STUDIES

A. Forensic Analysis in Curtailing Wildlife Trafficking: Case Studies from India

Illegal wildlife trading is a bane for all ecological diversities in India. Rhino horn trafficking and elephant poaching are a few examples of wildlife crimes that damage environmental integrity, as well as national conservation values. Such illegal acts endanger some iconic species of the country and, at the same time, affect the country's march towards achieving the United Nations Sustainable Development Goals (SDGs), namely SDG 15 - Life on Land, which aims to safeguard, restore, and promote sustainable use of terrestrial ecosystems and halt biodiversity loss.

Especially within this framework, forensic science has saddened the most powerful tool in the fight against wildlife crime and delivered the most coordinated sense of scientific analysis for the sake of justice. It links very well an offender directly to the crime scene and wildlife specimens by using concrete and admissible proof. Again, successful prosecutions of wildlife crimes have been generated in Assam and Kerala using advanced forensic techniques. Such efforts would be made not only in strengthening environmental governance but also in aligning the country's activities with SDG 16 on Peace, Justice, and Strong Institutions i.e. promotion of rule of law and reduction of wildlife crimes. Forensics should be an integral part of conservation strategies that echo sustainability and preservation of the country's rich natural heritages for the next generations[19].

B. Rhino Horn Trafficking in Assam

Kaziranga National Park, located in Assam, has for long been a hotspot for the poaching of rhinoceros. The high black-market demand for its horn, as well as the myth around their medicine and aphrodisiac value attached to them, has further propelled the menace. The Indian rhinoceros (Rhinoceros unicornis), a keystone species, remains constantly threatened by illegal wildlife trade. The year 2017 witnessed a landmark case that transformed the domain significantly for the criminal justice system in the pursuit of such crimes. Currently in use were advanced techniques like DNA profiling and stable isotope analysis to lead the tracing of confiscated rhino horns back to individual animals that were killed in Kaziranga. This scientific evidence proved crucial in establishing the origin of the horns, thereby facilitating prosecution against traffickers[20].

This case is indicative of the integral role of modern forensic tools in wildlife crime, which aligns with Sustainable Development Goal 15-Life on Land, emphasizing an immediate need in the protection, restoration, and promotion of the sustainable use of terrestrial ecosystems as well as halting biodiversity loss. Crackdown on both wildlife trafficking and SDG 16-Peace, Justice, and Strong Institutions-thereby improving the legal regime within which law enforcement operates and are accountable. Such species give one example of how sustainable development and biodiversity protection can go hand-in-hand in securing a more just and ecologically resilient future by science-based approaches in actions legal and conservation efforts.

C. The Involvement of Elephant Poaching and Ivory Trafficking in Kerala

Two years back, an important case in Kerala drew the country's attention to the need for stricter action against wildlife crime, specifically elephant poaching and trafficking in ivory. Two persons were arrested by enforcement agencies trying to illegally sell elephant ivories. The seized ivory was verified for origin and authenticity by forensic experts using techniques such as molecular and isotope analysis. Surprisingly, the results revealed that the ivory did not originate from India's native Asian elephants (Elephas maximus), but from African elephants (Loxodonta africana). This finding points to international smuggling networks and certainly underscores how the illegal wildlife trade involves transnational crime.

This is no longer only an issue for the wildlife lawyers of the world, but provides even greater agenda for various nations in international co-operation to tackle wildlife crime and its biodiversity conservations. It is very significant in the context of the steering efforts toward achieving the Sustainable Development Goals (SDGs) of the United Nations, especially SDG 15 (Life on Land), demanding immediate action to protect, restore, and promote the sustainable

of Science, Species Management, and the Law' [2021] Wildlife Biodiversity Conservation 163

[19] Priyono DS and others, 'From Confiscation to Conservation: Wildlife DNA Forensic for Species Identification of Confiscated Felidae in Indonesia' (2025) 367 Forensic Science International 112362

[20] Dalpane F and Baideldinova M, 'Poaching and Wildlife Trafficking as Threats to International Peace and Security' [2022] International Conflict and Security Law 861

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use of terrestrial ecosystems and halt biodiversity loss; as well as the standing significance to SDG 16 (Peace, Justice, and Strong Institutions), advocating for strengthened institutions to prevent crime and ensure justice. Illegal wildlife trade addresses not only species conservation but also sustains the ecological balance and sustainable development. Bringing back the Kerala case, the SDGs can only be achieved through international coordination, advanced scientific tools, and strong legal frameworks for protecting endangered species and ensuring a sustainable future[21].

D. Forensic Science in Wildlife Conservation

An important component in wildlife conservation and enforcement, forensic science provides advanced techniques to establish key links between poachers, traffickers, and wildlife products that have been legally obtained. Such scientific evidence plays a critical role in strengthening the prosecution's case against offenders, acting as a deterrent to future wildlife crimes. Accordingly, forensic science plays a key role in the investigation of wildlife crimes and the protection of India's rich biodiversity against illegal wildlife trade and is directly intertwined with the fulfilment of Sustainable Development Goal(SDG) 15) to protect life on land. Collating with such international actions assists in dislodging cross-border trafficking networks and enforcing wildlife protection laws effectively.

In September 2021, another glaring example of the relevance of forensic science emerged when Yunhua Lin was sentenced to 14 years in Malawi for his crime of trading in rhino horns illegally. Lin was the kingpin of this trafficking network, which has thriven illegally for the last decade or so. A wide range of investigations revealed a large store of contraband, ivory, pangolin scales, as well as 103 pieces of rhino horn. Forensic evidence, including the testimony of a poacher, tied him to the illegal rhino horn trade, pointing once again to the efficacy of forensic techniques such as DNA databases like RhODIS®. The importance of this case stems from the fact that it demonstrated the contributions of forensic databases in identifying and tracking trafficked wildlife goods, thereby giving credence to SDG 16 on peace, justice, and strong institutions[22].

The illegal transborder trade in wildlife products is causing numerous species to become virtually extinct and also to set up very lucrative syndicates. Rarely is wildlife poaching introduced through the transnational network that is illegal at all causing organized crime and needing new tactics to combat it? Forensics, especially recent advances in DNA profusions, have emerged as one of the best tools possible to fight wildlife crimes. These forensic tools trace animal products to their source, identify persons involved in wildlife crime, and help dismantle wildlife trafficking networks, thus creating much-needed momentum for SDG 16 by enhancing law enforcement contraction.

Forensic science is refining itself progressively into a discipline of wildlife protection, acting in its way, as in the case of an endangered species that derives illegal exploitation deterrent benefits. It is an aspect of some innovative developmental goals at the larger level, such as biodiversity conservation, crime-free development, and cooperation at the global level in addressing wildlife crime. The forensic science applied in wildlife conservation advances the achievement of SDGs 15 and 16 as well as lays the foundation for a future where environmental preservation through sustainable development becomes imperative for many generations[23].

DNA FORENSICS FOR IDENTIFYING WILDLIFE SPECIES

DNA forensics has considerably improved the identification of species in contraband wildlife products, within the framework of fighting against poaching and illegal wildlife trade. This well-established technology has become very accurate and accessible, lending itself easily to the differentiation of legal from illegal wildlife trade activities. Aligned with the United Nations Sustainable Development Goals (SDGs), especially SDG 15: Life on Land, DNA forensics supports efforts aimed at conserving biodiversity and ending wildlife trafficking. It further strengthens the capacity for effective conservation management with higher accuracy and reliability regarding compliance with wildlife laws. Thus, DNA forensics directly contributes to sustainability in the ecosystem and species conservation through promoting sustainable practices as well as sound regulatory

[21] Plowman C, 'Combating the Illegal Pangolin Trade - a Law Enforcement Practitioner's Perspective' [2020] Pangolins 293

[22] 'Research on Combating Illegal Wildlife Trade Based on an Integrated Regression and Enhanced Forecasting Model' (2024) 5 Information Systems and Economics

[23] *Ibid.*

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measures for both wildlife and people in the future.

A. *Stable Isotope Analysis for Determining Geographic Origin*

Stable isotope analysis serves as a cornerstone of evidence-based geography for tracing wildlife products' origin and fighting illegal wildlife trade. The employment of stable isotope analysis in biological matter-hair, feathers, bone, and teeth-determines what environmental conditions prevailed during the lifetime of the animal. Unique isotopic signatures within various regions enable forensic scientists to assign confiscated wildlife products to their true geographies.

This scientific process underlines the implementation of international legal frameworks and will further strengthen governance, accentuating peace and justice among nations. Ultimately, stable isotope analysis is then one of the instruments supportive of wildlife conservation, sustainable development, and a resilient, fair global environment.

B. *Forensic Entomology in Investigating Wildlife Crimes*

Forensic entomology dealing with insect study in cases has evolved into a credible means in the case of human crime and wildlife crime as well. Insects being a part of the natural decomposition of any animal remains give out crucial information for the forensic identification of time since death based on the type of insects found and stages of their life cycle. This method is especially useful to verify hunting permit, to authenticate criminal killing of animals, and to supervise compliance with wildlife trade-related legislation. Thus, assessing with precision the timeline of death by these forensic approaches embraces the enforcement of conservation laws and prosecution of illegal poaching activities.

C. *Remote Sensing Technologies for Wildlife Protection*

The real-time satellite images help in locating habitat degradation, illegal encroachment, and tracking the movement of endangered species, thereby allowing prompt and well-informed intervention. They also help strengthen the anti-poaching units and enhance their combating mechanisms against illicit wildlife trade in furtherance of conserving terrestrial ecosystems. Forensic science integrated with technology forms a strong armory for investigating and prosecuting wildlife crimes. Such measures lend credence to legal systems and conservation strategies designed to prevent and deter environmental crime. These represent a means of achieving sustainable development that aids ecosystem protection and secures the survival of endangered species for generations to come, as mentioned in SDG 15 and SDG 16: Peace, Justice and Strong Institutions[24].

D. *Advanced Forensic Techniques in Combating Poaching*

Up until October 2023, there were human beings teaching their creatures to distinguish good from bad in wildlife protection. Such advances are of importance to poaching, of importance in methods for individual animal identification and tracking. Biometric identification of animals is now using facial recognition and fingerprint analysis to allow researchers finally to build a comprehensive database documenting species with regard to specific attributes. With technology, it has become possible to accurately monitor animals over time, looking at their behavior, migratory patterns, and health indicators. The other major benefit of machine learning is that the classification algorithms increase the efficiency and accuracy of these systems many folds, thus giving a boost to anti-poaching activities through automating animal recognition and timely response in conservation efforts. Such efforts directly contribute to SDG 15 (Life on Land) through promoting the protection of terrestrial ecosystems and endangered species.

Moreover, the rise of genetic profiling as a forensic tool has strengthened the fight against illegal wildlife trade. Another forensic method at work is whereby DNA is extracted and analyzed from seized wildlife products, thus tracing them to individual animal sources or poaching networks.

Nevertheless, implementation of forensic technologies must occur within effective legal and institutional frameworks, because the impact of forensic evidence in the courts will depend on credible legislation and international collaboration for its purposes. In recognition of this, governments and international organizations are increasingly attempting to strengthen wildlife protection laws and promote cross-border partnerships. Such partnership possibilities, facilitated by bilateral and multilateral agreements, allow for the sharing of intelligence, coordinated

[24] Arkhipova MV and others, 'International Cooperation in the Fight against Environmental Crime: A Modern Mechanism for Combating Illegal Trade in Wildlife' [2020] Studies in Systems, Decision and Control 889

investigations, and joined-up operations in law enforcement. These actions are useful both for conserving certain species and for sustainable development through better governance and rule of law[25].

THE PROSPECTS FOR ANIMAL CRIME FORENSICS

With the advancements in DNA forensics, more traction has been gained in combating illegal wildlife trade (IWT) through the genetic analysis of trafficked animal species. They contribute not solely to the forensic capabilities but also to the biological understanding, which allows scientists and veterinarians to provide more justified and effective help in supporting wildlife acquisition from the hands of smugglers. A textbook case is the 2016 genomic sequencing of the Chinese and Malayan pangolins, which revealed much-needed knowledge about their health vulnerabilities. The absence of the interferon epsilon (IFNE) gene, which plays a role in mucosal immunity, and a reduced number of heat shock protein genes indicate the species' vulnerability to infection and stress-induced immunosuppression. Thus, it is these findings that demonstrate the complexity and immense risks associated with pangolin health management under human care due to the trafficking activity. DNA forensic science and conservation biology are essential to fight poaching and trafficking of protected species, which is an urgent target goal of the SDG 15 (Life on Land). The knowledge gained on the behavior, genetics, and health of the species in question will assist in formulating improved rehabilitation and conservation protocols. Furthermore, this will furnish the law enforcement and wildlife authorities with scientific backing for informed intervention and possibilities for evidence-based prosecution[26].

Unlike the human DNA typing systems, forensic analysis in the animal kingdom is faced with the challenge of species-specific variations in the short tandem repeat (STR) patterns. The genetic variability existing in animal species renders the utmost difficulty in coming out with a universally standardized STR testing protocol. Each of these disparities found in enforcement and investigation protocols presents a roadblock in wildlife forensic contexts where traffickers deliberately exploit genetically different populations. To tackle these challenges, a more multidisciplinary approach is needed, encompassing the validation of testing systems, development of reference databases, capacity building of humans, and strict regulations in laboratory practice.

A really robust wildlife forensic framework will require higher financial investment and collaboration between governments, research institutions, and conservation organizations, which forms the backbone of SDG 17. Such partnerships should focus on strengthening the forensic capacity at local and international levels. Empowered metropolitan local authorities should also carry the responsibility of enforcing biodiversity principles aligned to the tenets of SDG 16 (Peace, Justice and Strong Institutions).

To render global anti-trafficking interventions more effective, contemporary wildlife monitoring and alert systems need to be improved. National and regional provision of additional species-specific genetic technologies and highly equipped facilities can set up exclusive centers for wildlife identification, backed by very efficient sample dispatch protocols. Such facilities guarantee quality and time in case of investigation. Similarly, a central reporting mechanism would facilitate real-time sharing of data between authorities, thus speeding actions on enforcement[27].

An international platform is necessary to facilitate secure, varied, and regulated transfer of wildlife samples across borders under the CITES framework, pooling resources and expertise at the level of government and non-governmental organizations. Such a partnership will boost enforcement of wildlife law and contribute to SDG 13 (Climate Action) by enhancing biodiversity, which is a key element of developing eco-resilient systems and fighting the larger landscape effects of environmental degradation. The integration of genomic research, forensic science, and policy outcome coordination is the sustainable road toward fighting wildlife crime. By collaborative actions and scientific innovation, we will be able to fast-track global commitments toward biodiversity protection, justice, and sustainable development.

[25] Verma G and Kumar Yadav DrR, 'Through the Government's Lens: Nature's Cry — India's Battle Against Illegal Wildlife Trade' [2024] SSRN Electronic Journal

[26] Gore A, 'Investigating Transnational Organised Wildlife Crime' [2025] Global Financial Investigations 109

[27] Lowther J, 'Book Review: The Geography of Environmental Crime: Conservation, Wildlife Crime and Environmental Activism' (2018) 20 Environmental Law Review 129

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CONCLUSION

Combating illegal wildlife trade can be done by enacting legislation, employing strict enforcement measures, and providing significant judicial interventions. In particular, a coordinated comprehensive approach towards achieving meaningful and effective deterrent penalties, enforcement measures, and strengthened animal protection laws will complement the other SDGs, specifically SDG 15 (Life on Land), SDG 16 (Peace, Justice and Strong Institutions), and SDG 17 (Partnerships for the Goals). In addition, it would become imperative that judges and law enforcement undergo training regarding capacity building on effective ways of dealing with IWT offenses.

Combating global threats from IWT against biodiversity, ecological balance, and social ethics would require a strong global commitment, for that damage being done by wildlife crime deteriorates virtue by breeding both narrow individualism and rampant corrupt practices, erects barriers to good governance, and strengthens transnational organized crime networks and networks responsible for undermining the environmental integrity and integrity of institutions.

An ideal international response to the complex, legal and scientific problems arising from IWT should always be of cooperative international nature, involving governments, the environment, the laws, and the scientific community. Effective Modern technologization improves detection of wildlife crimes and processes in the courts, which significantly enhances protection of endangered species as well as the health of different ecosystems. By fostering cross-sectoral partnerships and integrating sustainability principles into enforcement strategies, the international community may meaningfully contribute to preserving global biodiversity and achieving broader targets of the 2030 Agenda for Sustainable Development.