Regulating Emerging Technologies in Wildlife Conservation: Legal and Policy Challenges of AI, Drones, and DNA Tracking in India

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Abstract. Wildlife conservation and enforcement strategies have been transformed drastically with the use of artificial intelligence, drones and DNA based forensic technology. To monitor wildlife habitats, prevent poaching and to strengthen evidentially base mechanism in wildlife crime prosecution these technologies are being employed by Indian agencies. These technologies have significant merit in conservation measures, however they raise complex constitutional questions that remain unaddressed within the present legal framework. In this paper, authors examine the limit to which India's wildlife conservation laws and policies are equipped to these technologies. It argues that though the agencies have embraced technology driven solutions, there is a need to evolve the legal framework. An examination of these technological tools are done which influence wildlife conservation in India. It explores the practical challenges behind the use of these technologies in wildlife crime detection and conservation, inclusive of questions of evidentiary reliability of data generated and continuing limitations in institutional capacity. Lastly, the paper examines the ethical dimensions of conservation policies based on technology specifically examining the risk of excessive surveillance and marginalization of local communities, underlying the debate that unregulated technological expansion is undermining legitimacy.

Keywords: Wildlife Conservation, Emerging Technologies, Wildlife Crime Enforcement, Environmental Law.

1 Introduction

In India, a combination of statutory frameworks, guidelines, policies shape the scheme of wildlife conservation. The central law streamlining the wildlife conservation strategies stem from the Wildlife (Protection) Act, 1972 and the Environment (Protection) Act, 1986. Along with these, other institutions such as the forest department, wildlife enforcement agencies also function to strengthen conservation measures. However, in spite of these systems, infrastructural issues and investigative hurdles are often seen pertaining to the protection and conservation of wildlife in India.

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Instances of organized illegal trading, poaching, illegal encroaching of forest area, etc. continue to challenge the enforcement and legal standards prevalent in India. Wildlife crime has been identified by conservationists as one of the most lucrative forms of crime globally, often connected through transnational criminal syndicates [1]. The enforcement agencies in India are operating extensively across ecologically diverse territories with limited manpower and logistical resources.

The traditional conservation approach which heavily rely on ground patrols, physical monitoring and the like are hugely resource intensive as well as reactive by design. In these approaches crime detection mostly occurs after the act has already taken place. On the other side, there has been tremendous increment in sophistication of wildlife crime networks which complicates the enforcement work and requires faster detection methods as well strategic allocation of limited resources. In such light, the scope of Artificial Intelligence (AI) should be expanded to governance structures in order to strengthen administrative and ecological frameworks.

AI in wildlife conservation shall not be incorporated merely as a technological modernized tool rather it shall be used as a tool to collect and generate ecologically sensitive data. In many countries, AI is being integrated with camera trap networks to automate species identification. Rather than reviewing thousands of photographs manually the algorithm uses machine learning, classifying species on pattern recognition models which are trained on labelled data sets. Through machine learning, these systems are capable of distinguishing individual animals by stripe configurations, spot distributions and morphological features. Through the use of AI, there is a clear reduction of time in undertaking data collection. This significant reduction in processing time will empower us with real time updates of population data. Research examining AI-assisted ecological monitoring has noted its capacity to scale analytical processes beyond what human teams can reasonably sustain [2].

AI beyond image classification can be employed for predictive modelling in wildlife crime prevention. By analysing official records, assessing terrain and seasonal patterns alongside environmental variables, AI can develop predictive systems to identify areas statistically vulnerable to poaching or other criminal activities. This development reflects a transformative approach towards governance where data forecasting directs enforcement planning. This transformative governance through prediction mirrors the development in other regulatory domains where algorithmic systems are used in risk assessment and compliance monitoring [3]. The actual potential of predictive tools in wildlife conservation remain in their potential to utilize escape resources optimally. In a country like India where protected areas span in vast hectares across ecologically varied terrain, the capacity to concentrate resources in vulnerable areas will end deterrence while at the same time reduce inefficiency.

Drone based surveillance alongside AI has become increasingly relevant to wildlife conservation governance. Aerial vehicles allow real time monitoring of vast, remote and difficult terrain empowering enforcement agencies by rapid detection of illegal encroachment, logging activities and the like. Drones expand observational capacity beyond the capacity that ground patrolling alone can achieve and have been increasingly adopted in protected area management globally [4]. This will capacitate enforcement agencies with situational awareness where physical access is limited.

However, one must be cautious that these aerial surveillances will introduce concern regarding operational apparatus, authorization of airspace and proportional deployment. As scholars examining conservation technologies have noted, the expansion of digital monitoring tools must be accompanied by governance safeguards to prevent regulatory ambiguity [5].

In addition to the above discussed two emerging technologies, DNA tracking and wildlife forensic technique adds a new tangent to emerging conservation technologies. Genetic profiling will empower enforcement agencies with precise species identification tracing, seized wildlife products to geographic origin and ultimately strengthening prosecution in wildlife crime cases. Advances in wildlife forensic science have significantly improved enforcement capacity, particularly in combating illegal wildlife trade networks [6]. It has become extremely imperative to develop chain of custody protocols, accreditation standards and methodological transparency in order to integrate DNA databases with Wildlife Conservation practices.

As the algorithmic outputs begin to aid and assist enforcement agencies, they are empowered with data predicting the positive likelihood of a criminal activity. This would make the authorities rely on digital dashboards, predictive outputs and machined learned classification systems. The importance accorded to these outputs will vary across institutions yet they would inevitably shape enforcement actions. As AI systems operate through statistical inference rather than deterministic certainty, it is thus advisable to adopt AI in wildlife conservation not only in a technical way, rather in the representation of institutional transformation in what the risk is and how the enforcement actions can be structured. Laws in India neither prohibit nor formally provide for the deployment of AI in wildlife protection which has led to administrative experimentation and non-articulated standards. As more and more drones are embedded within conservation workflows, the absence of structured guidance is becoming visible.

This paper is divided into four parts. Part one focuses on the introduction which emphasizes that technological transformation is currently underway in wildlife conservation. It positions the role of the emerging tools within the broader context of wildlife crime prevention and conservation governance. Part two of the paper focuses on examining the structural vulnerabilities and institutional risks which are associated with deployment of these technologies. It analyses how these emerging tools can reproduce data imbalance and disturb operational efficiency negatively impacting governance strategies through these tools. This section indicates that restructuring is required in the manner of administrative governance. Part three of the paper focuses on the statutory framework governing wildlife conservation. This aims to demonstrate that existing legal principles are capable of assimilating technological innovation yet they require structural and procedural articulation. Part four of the paper proposes a layered regulatory framework which must be incorporated to develop policy governing emerging technologies in wildlife conservation and strengthening the prevention of wildlife crime prevention.

2 Systemic Risks and Structural Vulnerabilities in Technology Driven Wildlife Governance

These days, a gradual acceptance of the use of AI monitoring devices is being seen. These tools are being rapidly employed to ease operational challenges faced by the enforcement agencies. These tools have started to assist and reshape the style of governance that is seen today. Machine learning models execute outputs using statistical correlation rather than causal understanding. Their outcomes are determined by data architecture, model design, and the premise embedded in training processes. When these outcomes begin to impact enforcement action plans, predictive policing, or monitoring depth, this technical architecture of AI acquires authoritative influence.

An underlying susceptibility is inherently due to the lack of uniform data and the imbalance in the distribution of conservation data. The current monitoring and surveillance systems are not placed uniformly in our country, due to which the algorithm data predict inconsistent results. At present, extensive ecological and enforcement records are generated through detailed surveillance of protected areas which significantly impact algorithms of these data driven models, thereby impacting predictions even for areas where surveillance and monitoring systems are placed scarcely. This is an inherent consequence of data driven modelling systems and not an intentional distortion of data, but these standardised results could impact enforcement actions in a less or a newly monitored area based on the data algorithm of a larger protected area.

A major concern with predictive systems is that they can reinforce structural imbalances embedded within historical data as consistently observed by research in algorithmic governance [7]. This is a continuing risk of technological over-reliance where it imposes its understanding of a limited sample to all conservation contexts [8]. Thus, it is significant that technological innovation must be aligned with equitable and context-sensitive governance frameworks [9].

Another aspect of vulnerability is classification error. There are different ways in which automated recognition species and AI-enabled camera nets perform under different conditions. There could be instances of partial visibility, partial occlusion, dense plantation or changes lights which can negatively impact the results generated. This environmental factors impact the most effective systems at present as well. However, misclassification can severely impact the assessment of biodiversity and its population with its results [10]. Errors in these digitally enabled mechanisms is quite severe. Vulnerable areas can be left out due to false negatives, or be insufficiently monitored, and can even divert attention to areas that do no showcase risk.

It has been observed that the reliability of these predictive models are compromised, due to their dynamic and adaptable nature. Basically these assessments are done on correlation of prior analyzed data and not necessarily predict with certainty. It is significant to note that due to actions from enforcement agencies, the wildlife crime networks also keep adapting themselves by changing their routes, targeting other species and likewise. And, as these predictive models function on historical data and thus are unable to predict new patterns.

On the other hand, drone surveillance relies on its software for object detection. To ensure this is effective, deployment of drones is necessary which requires compliance with aviation laws, accurate data capturing, conformity with chain of custody principles for it to be legally transmittable. This data capturing is again dependent on the environmental factors such as that density of the land, huge rainfall, and others challenging the reliability of the data. However, it is suggested that procedural legal safeguards must be met properly rather than dependence on advanced technologies, as these conversation models should be equipped with adaptive monitoring system based on variable environment factors [11]. Furthermore, DNA also uses algorithms to undertake analysis of genetic data which is based on comparative data analysis. In all these contexts, the output from these technologies become the central point in ensuring prevention of crimes and conservation governance in environment matters. The actions taken by regulatory agencies even have to be judicially aligned. However, in cases where these tools influence the direction of the investigation or allocation of resource, it can initiate scrutiny and also complicate conservation strategies [12].

Another concern that has been seen is that enforcement agencies majorly depend on these technologies for strengthen the investigation and its direction. This compromises with their investigative judgement and enforcement thereafter. It has been seen that stakeholders can depend largely on the results generated by the technology especially when it appears to be scientifically driven [13]. However, it is significant to note that the challenges that come with the use of these three technologies are any day led and created by humans, however it is significant to note that these challenges do not undermine the authority of these technologies but it certainly necessitates the need for safeguards to be employed for the use of these technologies.

3 Statutory, Evidentiary, and Constitutional Implications of Technology-Driven Wildlife Enforcement

The use of AI, drones and DNA tracking in wildlife conservation is considered extremely significant in such evolving times, however, the law is yet to come to pace with it. Though the administrative practice or the technology is ever evolving and dynamic in nature, the enforcement standards take time to adapt. This gap becomes significantly visible upon the popular use of evidence of aerial surveillance or of genetic identification becoming a core area in matters of wildlife investigations or prosecutions. This leads to a delay in justice processes due to the vacuum of legislative intent.

In India, the Wildlife (Protection) Act, 1972 is the foundational law for substantive, procedural and punitive enforcement of wildlife matters in India. The law provides procedures for search, seizure, arrest, while providing protection to wildlife specifies and regulation of activities. However, the same statute fails to highlight the significance of predictive analysis, DNA profiling or drone monitoring in undertaking the regulation activities. In fact, the statutory framework does not limit the power of the investigative agencies to only employ methods which are statutorily sound, thus enabling the investigative agencies to undertake use of technologically advanced driven methods to conduct investigations or prosecutions as per the law. The result obtained through the

tech driven systems may be completely technical but influences human objectivity in the prosecution of the case. This also raises a significant question of institutional accountability and reliability in the acceptance of these tech driven technologically advanced prosecution options, including questions of evidentiary admissibility as well.

The Bharatiya Sakshya Adhiniyam, 2023 is the law in force in India securing the standards for evidence admissibility in the court of law. Through statutory provisions such as the section 63 and through various judicial decisions which have laid emphasis that for ensuring the admissibility of an electronic evidence, it is important that procedural requirements must be met of authenticity and digital certification [14] [15]. These judicial precedents strengthen the procedural requirements for admissibility of electronic evidence. Additionally, evidentiary standards have been established for admissibility of DNA forensic evidence for evidence collected and examined through DNA tracking vide its section 39 [16].

Evidence obtained through advanced AI-generated devices introduces additional complexity, as predictive analysis may identify a location as high risk and call for an enforcement action to seize or protect wildlife. This influences the way environmental agents (here, wildlife protection officers) function and act. Though the AI generated evidence may not be admissible immediately in the court, the action undertaken by the wildlife protection officer influences the direction of investigation, raising questions of procedural sanctity. This is unlike the transparent conventional digital records securing chain of custody principles, but here algorithmic outputs derive data from layered modelling processes which can cause difficulty in establishing credibility in the court of law [17]. This concern is not limited to only AI generated evidence but also to drone imagery which requires compliance with electronic records as per the Bharatiya Sakshya Adhiniyam, and to also DNA analysis that demands strict laboratory protocols coupled with compliance with the chain of custody principles, in order to secure their admission in the court of law and strengthen procedure of forensic investigation as well [18].

Thus, scientific evidence is admissible post valid legal compliance of chain of custody principles. However, with the advent of the new data driven formats of evidence, it has become necessary that even algorithmic processing methods be validated in the courts of law. It has become necessary that a legal understanding pertaining to the algorithmic model designs, validation processes and error margins are also introduced to the court to secure their legal standards of admissibility.

The apex court of India has emphasised that all evidentiary processes must preserve fairness and reliability. Though all AI-based systems are not inherently unreliable, the prime characteristic is the manner in which this data has been developed, which raises some doubts. It is significant to understand that predictive data modelling does not establish cause but they strategically identify the prime likelihood of cause and thereafter predict results. This is the manner in which algorithmic assessments contribute to investigative reasoning but this assessment must stand the evidentiary standards laid down by the courts for their due effectiveness in the process of trial.

Additionally, these technologically advanced methods should also come in conformity with the principles of right to privacy under Article 21 of the Constitution of India [19]. It has become significant that all surveillance measures must secure

standards of legality, necessity, and proportionality [20]. Wildlife conservation is undeniably the objective of the State and so is protection of biodiversity and ecological balance. However, it has become significant that the measures which are adopted to ensure governance are in sync with the legal regime and are not disregarding the rights of its citizens.

The AI assisted monitoring systems such as those of sensor networks, camera traps and predictive surveillance can expand the scope and reach of the collected data. There exists a good possibility that the captured data would also capture human habitation or forest dependent communities of a protected area. These conservation monitoring systems certainly have not been deployed for human surveillance but the retention and storage of the recorded data without a clear understanding of its use, disposal can initiate constitutional scrutiny. The doctrine of proportionality does not state that technology mustn't be used, but it requires that the usage of such technology is structured and is reviewable.

Another significant question of law that arises within the scope of India, is the principle of procedural fairness. The use of the technology is not limited, but the principle asserts that the procedure through which an enforcement action is initiated must be fair, clear and certain. It is seen that, when enforcement decisions are based on the data secured through predictive models whose methodological understanding is limited, it brings barriers to effective application of the principle of procedural fairness thus negatively impacting stakeholders. Furthermore, the limited understanding of this nuanced method also raises questions on the application of the principle of transparency. Thus, it is necessary that the algorithmic patterns which are not easily comprehensible must be reconciled with statutory and institutional acceptance and acceptance be secured through judicial scrutiny in order to strengthen the principle of fairness and transparency.

At this juncture, it becomes significant to note that the deployment of such tech-driven systems which aims to assist the State in undertaking swift and a reliable action furthering wildlife conservation, have been predominantly developed by private agencies. These systems are privately owned though enforced by State agencies. Thus, in cases where these predictive models malfunction, or when a question of access to data arises, or a challenge is made to the reliability of the algorithmic dataset, then the accountability of the State is brought to scrutiny. It, thus, has also become necessary that statutory standards must be established which can ensure complete standardisation of the data, its use and access. Additionally, the State must also identify agencies or vendors whose dataset and hardware can be employed for the development of this infrastructure.

Thus, upon close examination, it is seen that the current Indian legal architecture lacks structural understanding in adapting this contemporary manner of wildlife prevention and conservation management. Though, the Wildlife (Protection) Act, the Bharatiya Sakshya Adhiniyam and the Constitution of India collectively provide for a technologically and legally sound system of governance model where the acceptability of the data driven technology is not a concern but the manner of its deployment, use and access is.

4 Structuring Responsible Governance of AI Monitoring, Drone Surveillance and DNA Tracking in Wildlife Conservation

For effective deployment of AI monitoring, drone surveillance and DNA tracking system into the wildlife conservation governance model and to strengthen their judicial acceptability, then their unregulated use within the enforcement systems needs to be revisited. Their deployment must be in sync with the evidentiary standards as per the legislative scheme of the country. This would grant them legal sanctity and secure their instrumental role in conservation of environment. The risks, as stated above, of opacity in processes, lack of transparency, ownership autonomy, and questions of reliability can be solved undeniably through regulatory additions. The challenge is not in granting legal acceptability to these tech-driven methods but to integrate them in an already existing framework. Once done, this would provide legal clarity, procedural fairness and secure accountability.

At first, the reform lies at the statutory level. Amendments should be brought to the Wildlife (Protection) Act recognising tech driven deployment of strategies for conservation management and wildlife crime prevention purposes. Beyond this, clear legislative recognition of the AI-enabled monitoring tools specifying the purpose of their use, standards of use, coupled with the algorithmic code that it would comprise of, manner of handling the data and empowering officers who are responsible to interpret the data. The intention behind empowering enforcement officers is that this would ensure consistent and systemic operationalisation of principles of validity, documentation and review. This will strengthen recognition of technological interface in the legal system and would enhance legal certainty.

Additional systems such as setting up of a dedicated team responsible for the management of the sensitive data, undertaking consistent recalibration of the data reflecting sensitive ecological and enforcement realities, as this data based on predictive analysis is inherently adaptable. It is clear this data and these digital systems need to be monitored consistently to avoid chances of error in predictive policing. Moreover, clear policies pertaining to how should the data be retained, control of access to data, management of chain of custody in case the data is transferred to law enforcement authorities, restricted use in case a human habitation has been recorded keeping in view the constitutional jurisprudence of governance in India.

Human intervention and oversight constitutes the second critical layer in adequate governance with these technologies. AI tools, drone surveillance, DNA tracking systems, should not act as autonomous systems but should be employed as decision support systems. The presence of the human in managing this data is significant as it ensures independent evaluation of the enforcement decisions and avoids any automation bias which these digital technologies are prone to. This also ensures procedural security and secures operational efficiency.

Apart from this, independent audits must be conducted to ensure institutional resilience. Technical supervision must also be performed by external experts to ensure accuracy of algorithm, and to further avoid bias and ensure recalibration accuracy.

Review committees must be established consisting of lawyers, scientists, engineers to conduct periodical visits. This will aid in securing the quality of the quality of the systems and ensure reduction of vulnerabilities or false decisions.

Finally, digital devices must be deployed keeping in mind the sensitivity of the community [21]. Transparent and clear communications should be done from the State to forest dependent populations clearly defining the scope and objectives of AI use, drone surveillance and DNA tracking. Consultative meetings should also be arranged with the community ensuring trust and reliance on each other [22]. This way futuristic conservation governance is coupled with social dialogue leading to trust in each other.

Taken together, through statutory amendments, enforcement procedural standards, presence of human oversight, independent audit mechanisms, capacity building and community engagement, we will be able to establish a coherent regularity architecture [23]. This way, we are incorporating an innovative model with accountable results.

5 Conclusion

The integration of AI, drone surveillance and DNA tracking into wildlife conservation represents a shift in the governance model, which will not only assist in identification of species, mapping of risks, monitoring of habitat and planning of effective enforcement strategies in order to prevent wildlife crimes. Till today, wildlife crimes continue to remain organised, adaptive and transnational in nature [24]. It is important that global agencies should join hands beyond their scope of biodiversity and aim to ensure conservation of wildlife [25]. To ensure this, sophisticated algorithms will add volumes. However, only strategic use of these technologies can assist as there is a possibility of classification error, opacity or automation bias in systems [26].

The legal framework was not drafted keeping in mind the sophisticated digital technology or nuanced legal standards but their presence in the enforcement systems will ensure reliability and secure procedural integrity and transparency. This also ensures that standards of privacy are also maintained through human intervention [27].

Together, AI, Drone and DNA Tracking showcases a lot of potential to strengthen wildlife conservation in India as the need of the hour is to integrate innovation with legality and to function within a framework which is transparent, cohesive, reliable and in conformity with the constitutional norms.

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