



ENHANCING WILDLIFE TRADE ENFORCEMENT IN MALAYSIA: A REVIEW OF THE ROLE OF DISRUPTIVE TECHNOLOGIES AND MULTI-STAKEHOLDER COLLABORATION

Mohd Hairul Mohd Salleh

Quality and Innovation Unit, Strategic Planning Branch, Corporate Planning Division, Royal Malaysian Customs Department, Malaysia Email: mhairul.salleh@customs.gov.my (penulis berkorespondensi)

ARTICLE INFORMATION

ARTICLE HISTORY

Received

21 August 2024

Accepted to be published

31 December 2024

KEYWORDS:

Illegal wildlife trade (IWT)

Disruptive technologies

Multi-stakeholder

Collaboration

DNA barcoding

Blockchain

Biodiversity protection

ABSTRACT

Perdagangan satwa liar ilegal (IWT) merupakan ancaman signifikan terhadap keanekaragaman hayati dan ekosistem global, dengan Malaysia menjadi titik transit penting bagi para penyelundup karena kekayaan keanekaragaman hayatinya. Tinjauan ini menganalisis integrasi teknologi disruptif dan peran kolaborasi antara berbagai pemangku kepentingan dalam meningkatkan pengelolaan dan penegakan peraturan perdagangan satwa liar di Malaysia. Tiga langkah utama menggambarkan metodologi yang digunakan dalam makalah tinjauan ini, termasuk strategi pencarian, kriteria inklusi dan eksklusi, serta proses pemilihan. Teknologi utama seperti pemrograman DNA, blockchain, drone, RFID, sistem deteksi otomatis, dan pengawasan siber berbasis AI dianalisis untuk potensi mereka dalam meningkatkan kemampuan pelacakan, pemantauan, dan penegakan. Tinjauan ini menyoroti studi kasus yang berhasil dan mengidentifikasi tantangan dalam penerapan teknologi-teknologi ini, termasuk kompleksitas, biaya, dan kebutuhan akan pengembangan kapasitas. Selain itu, tinjauan ini menekankan pentingnya upaya kolaboratif antara lembaga pemerintah, LSM, komunitas lokal, dan badan internasional untuk secara efektif memberantas IWT. Dengan mengatasi kesenjangan pengetahuan ini dan memanfaatkan strategi teknologi dan kolaboratif, Malaysia dapat meningkatkan kemampuannya untuk melindungi keanekaragaman hayatinya dan berkontribusi pada upaya konservasi global.

The illegal wildlife trade (IWT) poses a significant threat to biodiversity and ecosystems globally, with Malaysia being a crucial transit point for traffickers due to its rich biodiversity. This review examines the integration of disruptive technologies and the role of multi-stakeholder collaboration in enhancing the management and enforcement of wildlife trade regulations in Malaysia. Three main steps outline the methodology used in this review paper including search strategy, inclusion and exclusion criteria, and selection process. Key technologies such as DNA barcoding, blockchain, drones, RFID, automated detection systems, and AI-based cyber surveillance are examined for their potential to improve tracking, monitoring, and enforcement capabilities. The review highlights successful case studies and identifies the challenges in implementing these technologies, including complexity, cost, and the need for capacity building. Moreover, it underscores the importance of collaborative efforts among government agencies, NGOs, local communities, and international bodies to effectively combat IWT. By addressing these knowledge gaps and leveraging both technological and collaborative strategies, Malaysia can enhance its capacity to protect its biodiversity and contribute to global conservation efforts.

1. INTRODUCTION

1.1. Background of Study

Illegal wildlife trade (IWT) poses a significant threat to biodiversity, ecosystems, and the sustainability of wildlife populations globally, with Malaysia being particularly vulnerable due to its status as a biodiversity hotspot

Effective management and enforcement are critical to combating this issue, necessitating innovative solutions and collaborative efforts. Disruptive technologies such as blockchain, artificial intelligence (AI), and drones can revolutionize customs operations and wildlife trade management by

enhancing tracking, monitoring, and enforcement capabilities (Sazdovska et al., 2022).

Blockchain technology can provide transparent and immutable records of wildlife trade transactions, reducing opportunities for corruption and ensuring compliance with regulations like the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Ramadanti et al., 2023). AI can be employed to analyze patterns in wildlife trade data, predict trafficking routes, and identify high-risk shipments, thereby enabling more targeted and efficient enforcement actions (Mozer and Prost, 2023).

Drones can be used for real-time monitoring of protected areas, detecting illegal activities such as poaching and habitat destruction, and providing critical data for rapid response teams (Rios, 2024).

Multi-stakeholder collaboration is equally essential, involving government agencies, non-governmental organizations (NGOs), local communities, and international bodies. For instance, community involvement in conservation programs can provide sustainable livelihood options, reducing dependency on illicit activities and fostering local stewardship of wildlife resources (Raja, 2024). Additionally, international cooperation is crucial for addressing the transnational nature of IWT, as seen in the need for coordinated efforts between source, transit, and destination countries (Mozer and Prost, 2023). The implicit research question appears to be "How can disruptive technologies and multi-stakeholder collaboration enhance wildlife trade enforcement in Malaysia?"

In Malaysia, the illegal trade of species like porcupines, driven by the demand for traditional Chinese medicine, highlights the need for stringent enforcement and public awareness campaigns to reduce demand and protect wildlife populations (Gomez and Min-Sheng, 2024). The primary knowledge gap identified is the need for a comprehensive understanding and integration of disruptive technologies and multi-stakeholder collaboration to combat illegal wildlife trade in Malaysia. While various technologies and collaborative efforts have been piloted, there is a lack of consolidated information on their effectiveness, challenges, and best practices. Additionally, the coordination between different agencies and stakeholders, and how these innovative approaches can be scaled and sustained over time, needs further exploration. Therefore, this review examines the integration of disruptive technologies in customs and the role of multi-stakeholder collaboration in managing and enforcing wildlife trade in Malaysia. By integrating disruptive technologies and fostering multi-stakeholder collaboration, Malaysia can enhance its capacity to combat IWT effectively, thereby safeguarding its rich biodiversity and contributing to global conservation efforts.

2. LITERATURE REVIEW

2.1. Authority of The Royal Malaysian Customs Department

The Royal Malaysian Customs Department (RMCD) plays a pivotal role in enforcing wildlife trade regulations, leveraging Malaysia's strategic location as a transit point for illegal wildlife trade. This enforcement is crucial as Malaysia has become a key hub for smuggling activities involving wildlife products such as ivory, pangolin scales, and other endangered species. The RMCD collaborates with international and national agencies to curb this illegal trade, which poses a severe threat to global biodiversity and contributes to the decline of

endangered species. In 2022, the RMCD recorded 23 wildlife smuggling cases with seizures valued at RM73.4 million, investigated under the Customs Act 1967 and the International Trade in Endangered Species Act 2008 (Malaymail, 2022; United Nations, 2017). This aligns with broader global efforts to combat wildlife crime, as seen in other regions like China and India, where significant strides have been made in combating wildlife smuggling through multi-agency operations and stringent enforcement measures (Kuswanda et al., 2023; Song et al., 2023). The RMCD's efforts include seizing illegal wildlife shipments, conducting investigations, and participating in multi-agency operations like Operasi Bersepadu Khazanah (OBK).

Additionally, the RMCD, in partnership with organizations such as TRAFFIC, conducts training for customs officers on wildlife identification and smuggling techniques, enhancing their ability to detect and intercept illegal wildlife shipments. This training is part of broader efforts to ensure Malaysia does not continue to be used as a transit hub for wildlife smuggling (TRAFFIC, 2013). The importance of such initiatives is underscored by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which classifies species based on their threat levels and mandates international cooperation to protect them (Ramadanti et al., 2023; Wardono et al., 2022). By enforcing these regulations and participating in international conventions like CITES, the RMCD helps mitigate the impact of illegal wildlife trade and supports global conservation efforts, highlighting the need for a multidimensional stakeholder approach to effectively deter wildlife crime (Kuswanda et al., 2023).

2.2. Disruptive Technologies in Customs

2.2.1. Royal Malaysian Customs Department (RMCD)

RMCD is actively leveraging innovative technologies to combat illegal wildlife trade, enhancing the effectiveness of monitoring, tracking, and enforcement (Figure 1) through collaboration among various agencies such as the Department of Chemistry Malaysia, the Malaysian Forestry Department, the Malaysian Quarantine and Inspection Service (MAQIS), and the Department of Wildlife and Parks, Peninsular Malaysia (DWNP). DNA barcoding is employed to identify species through genetic analysis, ensuring accurate categorization and prosecution of trafficked items (Gomez and Min-Sheng 2024; Mohd-Salleh et al., 2023). Blockchain technology creates an immutable record of wildlife products, ensuring traceability and transparency in the supply chain to prevent illegal products from entering the market (Gomez and Min-Sheng, 2024; Ogden et al., 2008). Drones and aerial surveillance are used for real-time monitoring of protected areas, detecting illegal activities such as poaching and habitat destruction (Gomez and Min-Sheng 2024; Wich and Koh, 2018). RFID tags monitor the movements of wildlife and

products, making it harder for traffickers to move illegal items undetected (Gomez and Min-Sheng 2024; Ng et al., 2020). Automated detection systems at borders, including X-ray machines and portable analyzers, identify concealed wildlife products, enhancing border security (Gomez and Min-Sheng, 2024; Gujar et al., 2018). Cyber surveillance and AI monitor online marketplaces and social media for illegal wildlife trade activities, enabling timely action against suspicious transactions (Gomez and Min-Sheng, 2024; Fischer, 2021). Satellite imagery and remote sensing provide high-resolution images for monitoring large areas and detecting illegal logging or mining activities that threaten wildlife habitats (Gomez and Min-Sheng, 2024; Tarmizi and Rizwan, 2024). Mobile applications enable the public and field officers to report illegal activities or wildlife trafficking, providing authorities with precise information through features like geotagging and photo uploads (Gomez and Min-Sheng, 2024; Nor et al., 2022). Enhanced forensic techniques, including chemical analysis and isotope tracing, determine the origin of wildlife products, trace the supply chain, and identify poaching hotspots (Gomez and Min-Sheng, 2024; Ogden, 2016). These technologies, combined with efforts to raise public awareness and enhance enforcement of existing laws, are significantly improving wildlife protection in Malaysia and setting a precedent for other countries facing similar challenges (Tambi et al., 2023; Perry et al., 2010).

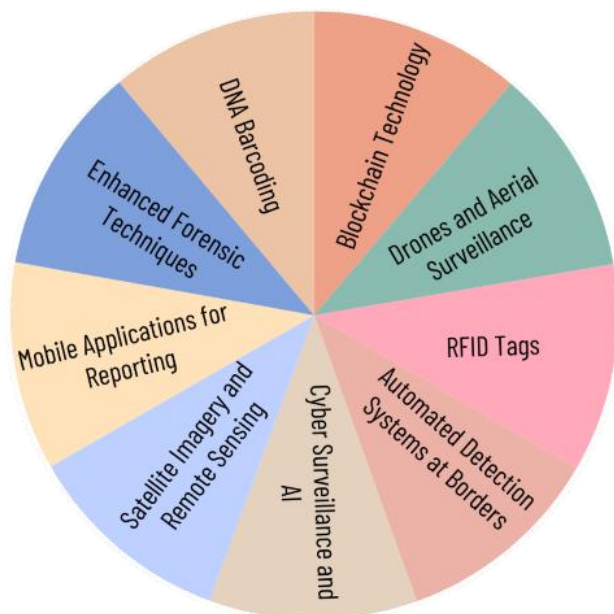


Figure 1. Innovative technology diagram points to combat illegal wildlife trade in Malaysia

2.2.2. Global Customs

In recent years, disruptive technologies (Table 1) have emerged as powerful tools in combating illegal wildlife trade. These technologies provide innovative solutions for tracking, monitoring, and analyzing

wildlife products and activities, enhancing the efficiency and effectiveness of customs operations.

Table 1. A summary of the disruptive technologies in customs and their applications globally

Technology	Description	Applications
Blockchain Technology (Tokkozhina et al., 2022; Zhang et al., 2021; Raj et al., 2020)	Transparent and immutable ledger system to enhance traceability and transparency of wildlife trade transactions.	Traceability: Ensures verifiable origins of wildlife products. Transparency: Open and secure platform for monitoring transactions. Accountability: Holds traders accountable for the legality of their products.
Internet of Things (IoT) (Das et al., 2022; Tokkozhina et al., 2022)	IoT devices monitor and track wildlife products in real-time, providing continuous data on location and condition.	Real-time Tracking: Monitors movement of wildlife products. Condition Monitoring: Ensures optimal storage and transport conditions. Alert Systems: Sends alerts for route or condition deviations.
Artificial Intelligence (AI) and Machine Learning (Moloney and Chaber, 2024).	Analyzes vast amounts of data to identify patterns and anomalies in illegal wildlife trade.	Predictive Analytics: Identifies potential illegal trade patterns. Image Recognition: Analyzes surveillance images to detect trafficking. Natural Language Processing: Monitors online platforms for illegal trade activities.
Drones and Unmanned Aerial Vehicles (UAVs) (Kretser et al., 2017)	Monitors remote areas to detect illegal wildlife trade activities, providing a cost-effective way to patrol large areas.	Surveillance: Monitors remote and hard-to-reach areas. Detection: Identifies illegal wildlife trade activities. Data Collection: Gathers data for further analysis and enforcement actions.

2.2.3. The Species Commonly Involved in Wildlife Trade Cases Handled by The Royal Malaysian Customs Department (RMCD)

The RMCD plays a pivotal role in enforcing wildlife trade laws in Malaysia, a country that serves as a significant transit point for illegal wildlife trade due to its strategic location. Among the top species

commonly involved in wildlife trade cases are pangolins, elephants, tigers, turtles, tortoises, orangutans, birds, reptiles, bears, rhinoceroses, and various fish and marine species. Pangolins are heavily trafficked for their scales and meat, which are considered delicacies and used in traditional medicine, while elephants are targeted for their ivory, leading to significant poaching and smuggling activities (Gomez and Min-Sheng, 2024). Gomez, and Min-Sheng (2024) stated tigers are trafficked for their bones, skins, and other body parts, primarily for use in traditional medicine and as luxury items (Gomez, and Min-Sheng, 2024). Turtles and tortoises, including species like the Ploughshare tortoise and the Asian giant softshell turtle, are traded for their meat, and shells, and as pets (Gomez and Min-Sheng, 2024). Orangutans are trafficked mainly for the exotic pet trade and sometimes for bushmeat (Ramadanti et al., 2023). Various bird species, including parrots and hornbills, are traded for their feathers and as pets (Gomez, and Min-Sheng, 2024). Reptiles such as snakes, lizards, and crocodiles are trafficked for their skins, as exotic pets, and for use in traditional medicine (Gomez and Min-Sheng, 2024). Bears, particularly the sun bear, are trafficked for their bile used in traditional medicine and other parts (Gomez and Min-Sheng, 2024). Rhinoceroses are targeted for their horns, highly valued in traditional medicine and as status symbols (Gomez and Min-Sheng, 2024). Fish and marine species, including seahorses, are trafficked for their purported medicinal properties and as exotic pets (Gomez and Min-Sheng, 2024). The complexity of these smuggling networks necessitates significant international cooperation to address, with the Royal Malaysian Customs Department working alongside other agencies to combat these illegal activities through stringent enforcement and international collaboration (Tambi et al., 2023; Kamaruddin and Zin, 2022). The enforcement challenges are compounded by inadequate penalties and outdated laws, which fail to act as effective deterrents (Zakuan 2023). Therefore, enhancing public awareness, improving law enforcement, and fostering a cultural shift toward recognizing the intrinsic worth of animals are crucial steps in mitigating wildlife crimes in Malaysia (Tambi et al., 2023).

2.2.4. Multi-Stakeholder Collaboration

Effective management and enforcement of wildlife trade in Malaysia necessitate a multi-stakeholder collaboration involving government agencies, NGOs, local communities, and international bodies. Government agencies are pivotal in policy formulation, enforcement, and capacity building, ensuring a coordinated approach to combating illegal wildlife trade. This includes developing regulations, implementing laws, and providing training and resources for effective enforcement (Tambi et al., 2023). NGOs play a crucial role through advocacy, research, and conservation initiatives, raising

awareness about the impacts of illegal wildlife trade and supporting on-the-ground conservation efforts (Rios 2024). Local communities, often the first line of defense, can be empowered through education and economic incentives to reduce their involvement in illegal activities and promote conservation. This involves raising awareness about wildlife conservation, providing alternative livelihoods, and engaging communities in monitoring and reporting illegal activities (Tambi et al., 2023). International bodies like CITES are essential for addressing the transnational nature of illegal wildlife trade by setting international standards, facilitating cooperation among countries, and providing support and resources to member countries (Kuswanda et al., 2023). The importance of a multi-stakeholder approach is underscored by the need for diverse disciplines and collaborators to develop effective strategies, as seen in the successful implementation of transdisciplinary approaches in combating illegal wildlife trade globally (Rios, 2024). Additionally, the collaboration among stakeholders in the ecotourism sector in Malaysia highlights the significance of governance practices and stakeholder engagement in sustainable development (Ibrahim et al., 2022). The multi-stakeholder approach not only enhances resource access but also ensures a coherent and comprehensive solution to wildlife trade issues, drawing on the full range of technical, human, knowledge, physical, and financial resources embedded in all sectors and among all actors (Kandilige and Ampah, 2023).

3. RESEARCH METHODOLOGY

Three main steps outline the methodology used in this review paper including search strategy, inclusion and exclusion criteria, and selection process. A comprehensive literature search was carried out using multiple databases, including Google Scholar, Scopus, and PubMed, to gather relevant academic articles, reports, and case studies on wildlife trade, enforcement technologies, and collaborative approaches. The keywords used for the search included “illegal wildlife trade (IWT),” “disruptive technologies in customs,” “multi-stakeholder collaboration,” “blockchain,” “AI-based surveillance,” and “Malaysia wildlife enforcement.”

The review focused on studies published in the last 10 years (2014–2024) to ensure the inclusion of recent advancements in technology and wildlife trade management. Only English-language papers discussing wildlife trade enforcement and disruptive technologies were considered. Studies were excluded if they lacked relevance to Malaysia or did not focus on enforcement technologies or collaboration strategies.

Abstracts of identified studies were first screened for relevance, and full-text articles were reviewed for eligibility. A total of 50 articles were included in the final analysis, representing a mixture of primary

research studies, review articles, and case studies from international and regional contexts, including those with specific applications to Malaysia.

4. RESULTS AND FINDINGS

4.1. Case Studies

To combat the illegal wildlife trade, various innovative technologies have been piloted in different regions around the world (Table 2). These technologies have demonstrated significant potential in enhancing the monitoring, tracking, and enforcement efforts against wildlife trafficking.

Table 2. A summary of the case studies

Case Study	Location	Technology Used	Description	Outcome
Blockchain in Wildlife Trade Management (Shen et al., 2023)	Kenya	Blockchain	Recorded every transaction on a blockchain to track ivory shipments from source to market.	Significantly reduced opportunities for illegal ivory trade.
IoT for Real-time Monitoring (Dlodlo 2012).	South Africa	IoT, Sensors, RFID Tags	Monitored rhino horns during transportation, providing real-time data on location and condition.	Enabled timely interventions in case of route deviations.
AI in Customs Operations (Petrossian et al., 2016)	United States	AI, Machine Learning	Analyzed data from surveillance cameras to detect patterns of illegal wildlife trade.	Successfully identified illegal activities, leading to arrests and prosecutions.
Drones for Surveillance (Mishra and Mitra, 2019).	India	Drones	Deployed drones to monitor wildlife sanctuaries and detect poaching activities.	Provided real-time video feeds for quick response to suspicious activities.

4.2. Challenges

Integrating disruptive technologies such as blockchain, the Internet of Things (IoT), artificial intelligence (AI), and machine learning into existing customs systems presents significant challenges, including complexity and cost. These technologies have the potential to transform border management and international trade by improving the efficiency of customs processes and easing the flow of goods across borders. However, the implementation of such technologies requires substantial investment and a strategic approach to manage the integration process effectively. Ensuring data privacy and security is another critical concern, as advanced technologies collect and process vast amounts of sensitive information. The development of digital ecosystems and innovative tools specifically designed for identifying suspicious signals in trade and financial transactions can enhance the detection of financial crimes and ensure compliance with regulatory requirements (Irina et al., 2024). Effective collaboration among stakeholders, including customs authorities, financial intelligence units, the private sector, and academia, is essential to overcome bureaucratic hurdles and foster trust. Recommendations for scaling up these technologies have been provided through various forums and workshops, emphasizing the need for a collective effort from all parties involved. The World Customs Organization (WCO) and the World Trade Organization (WTO) have also highlighted the importance of collaboration in their updated Study Report on Disruptive Technologies, which was prepared with input from member customs administrations and other stakeholders. Additionally, the role of smart customs in enabling global trade has been underscored, with IoT devices facilitating the autonomous monitoring of cargo and tracking of journeys, thereby minimizing customs clearance time and costs. By addressing these challenges through innovative approaches and collaborative efforts, customs authorities can create more efficient and secure global supply chains (William, 2018).

5. CONCLUSIONS

5.1. Conclusion

The integration of disruptive technologies and multi-stakeholder collaboration presents a transformative approach to combating illegal wildlife trade in Malaysia. By employing advanced tools such as DNA barcoding, blockchain, drones, RFID, automated detection systems, and AI-based cyber surveillance, alongside fostering cooperative efforts among government agencies, NGOs, local communities, and international bodies, Malaysia can significantly enhance its capacity to track, monitor, and enforce wildlife trade regulations. These innovations not only address the complexity and cost

of implementing new systems but also strengthen the collaborative framework necessary for sustainable and effective wildlife protection. Consequently, this combined strategy can safeguard Malaysia's rich biodiversity and contribute to broader global conservation efforts.

5.2. Recommendation

Investment in disruptive technologies, capacity building, and strengthening collaboration are critical strategies for enhancing wildlife trade management. Governments and organizations should prioritize investment in technologies that can disrupt illegal wildlife trade networks (WTNs) by improving supply chain visibility and tracking, which is essential for disrupting illicit networks and preventing negative collateral impacts (Meredith et al., 2023). The U.S. Fish and Wildlife Service's Law Enforcement Management Information System (LEMIS) exemplifies the importance of comprehensive data systems, though it also highlights the need for better data quality assurance and management standards (Weissgold, 2024). Training programs for customs officers and other stakeholders are crucial to equip them with the skills needed to effectively use these new technologies. This capacity building can help mitigate the challenges posed by insufficient penalties, corruption, and scarce resources in law enforcement, as seen in the context of India's wildlife trade issues (Raja, 2024). Strengthening collaboration among stakeholders is equally important. A transdisciplinary approach that converges knowledge from social, socio-ecological, and business fields can incentivize communities to combat illegal wildlife trade (IWT) by integrating criminal justice, environmental economics, and conservation initiatives like ecotourism (Rios, 2024). Additionally, international cooperation is vital for addressing the transnational aspects of wildlife trafficking, as coordinated efforts with destination nations can help reduce the demand for endangered species (Raja, 2024). The emergence of zoonotic diseases, such as COVID-19, underscores the urgency of managing wildlife trade risks through adaptive risk management and innovative program implementation, which require collaborative efforts and systematic evaluations to ensure effective and sustainable interventions (Stephen et al., 2022). By investing in technology, building capacity, and fostering collaboration, stakeholders can create a more robust and coordinated approach to wildlife trade management, ultimately supporting global conservation efforts and sustainable development.

Acknowledgement

This paper was presented at the 4th WCO RTC Indonesia International Conference 2024: Building A Seamless Future Through Disruptive Technologies in Customs and Multi-Stakeholder Collaboration, held in a hybrid format on October 8-9, 2024, in Jakarta, Indonesia. The authors would like to express their

gratitude to Pusat Pendidikan dan Latihan Kastam dan Eksais Indonesia, recognized as the World Customs Organization Regional Training Centre for Asia Pacific, for inviting this presentation. We also extend our appreciation to Direktorat Jenderal Bea dan Cukai Indonesia and Politeknik Kewangan Negara STAN for their cooperation in organizing this conference. Special thanks go to our colleagues at the Royal Malaysian Customs Department for their support and contributions to this research.

REFERENCES

- Das, L., Sharma, S., Yadav, S. A., & Dadhich, K. (2022). Application of blockchain technology in an IoT-integrated framework. In *Information Security Practices for the Internet of Things, 5G, and Next-Generation Wireless Networks* (pp. 131-151). IGI Global.
- Dlodlo, N. (2012). Adopting the Internet of Things technologies in environmental management in South Africa. IACSIT Press. <http://hdl.handle.net/10204/5981>
- Fischer, C. (2021). Illegal Wildlife Trade at the Philippine-Southeast Asian Nexus: An Assessment of Projects combating Illegal Wildlife Trade in Southeast Asia informing the Philippines and guiding Donor Coordination. *Asian Development Bank, Manila, Philippines*.
- Gomez, L., & Min Sheng, K. (2024). The Trade of Porcupines in Malaysia With International Trade Links. *Tropical Conservation Science*, 17, 19400829241236311. Irina, Revak., Oleg, Pidkhomnyi., Valeriia, Prokopenko., Artur, Zubrytskyi. (2024). Innovation's, and civil servants' behavioral models' influence on the formation of customs authorities' and financial intelligence units' cooperation and document exchange institutional conditions. doi: 10.36887/2415-8453-2024-1-16.
- Gujar, G., Ng, A. K., & Yang, Z. (2018). *Contemporary container security*. Palgrave Macmillan.
- Ibrahim, S., Amirrudin, A. H., Kamaruzzaman, S. A., Basri, H. H., & Salehuddin, N. (2022). Intersection Between Stakeholder's Collaboration and Governance Practices for Sustainable Ecotourism: A Literature Review. *Asian Journal of Arts, Culture and Tourism*, 4(3), 45-50.
- Kamaruddin, N. S. B., & Zin, N. M. (2022). Legal Challenges in Combating Child Trafficking in Malaysia. *IJUMJ*, 30, 180.

- Kandilige, L., & Ampah, G. A. (2023). Multi-stakeholder approach for dealing with Trafficking in Persons: The case of Ghana. *Ghana Journal of Geography*, 15(3), 92-126.
- Kretser, H., Stokes, E., Wich, S., Foran, D., & Montefiore, A. (2017). Technological innovations supporting wildlife crime detection, deterrence, and enforcement. *Conservation criminology*, 155-177.
- Kuswanda, W., Hutapea, F. J., & Setyawati, T. (2023). The Endangered long-tailed macaque is considered a pest in North Sumatra, Indonesia. *Oryx*, 57(1), 12-13.
- Malaymail. (2022, December 9). Customs Dept records 23 wildlife smuggling cases this year, RM73.4m in seizures. Retrieved from the Malymail website: <https://www.malaymail.com/news/malaysia/2022/12/09/customs-dept-records-23-wildlife-smuggling-cases-this-year-rm734m-in-seizures/44295>.
- Meredith, L., Gore, E., Griffin, Bistra, Dilkina, Aaron, M., Ferber, Stanley, E., Griffis, Burcu, B., Keskin, John, Denis, Macdonald. (2023). Advancing interdisciplinary science for disrupting wildlife trafficking networks. *Proceedings of the National Academy of Sciences of the United States of America*, 120 10(10):e2208268120. doi: 10.1073/pnas.2208268120.
- Mishra, M., & Mitra, A. (2019). Technology and wildlife crime: an appraisal in India. *Int. J. Innov. Technol. Explor. Eng. (IJITEE)*, 8.
- Mohd Salleh, M. H., Esa, Y., & Mohamed, R. (2023). Global Terrapin Character-Based DNA Barcodes: Assessment of the Mitochondrial COI Gene and Conservation Status Revealed a Putative Cryptic Species. *Animals*, 13(11), 1720.
- Moloney, G. K., & Chaber, A. L. (2024). Where are you hiding the pangolins? screening tools to detect illicit contraband at international borders and their adaptability for illegal wildlife trafficking. *Plos one*, 19(4), e0299152.
- Mozer, A., & Prost, S. (2023). An introduction to illegal wildlife trade and its effects on biodiversity and society. *Forensic Science International: Animals and Environments*, 3, 100064.
- Ng, C. H., Ng, K. K. S., Lee, S. L., Tnah, L. H., Lee, C. T., & Zakaria, N. F. (2020). A geographical traceability system for Merbau (*Intsia palembanica* Miq.), an important timber species from peninsular Malaysia. *Forensic Science International: Genetics*, 44, 102188.
- Nor, N. M., Majid, M. A., & Wahab, A. A. (2022). Potential Application of Artificial Intelligence In Safeguarding Malaysia-Thailand Border From Migrant Smuggling Activities: A Preliminary Assessment. *RES MILITARIS*, 12(2), 7213-7226.
- Ogden, R. (2016). Forensics in transnational environmental crime. In *Handbook of Transnational Environmental Crime* (pp. 388-410). Edward Elgar Publishing.
- Ogden, R., McGough, H. N., Cowan, R. S., Chua, L., Groves, M., & McEwing, R. (2008). SNP-based method for the genetic identification of ramin *Gonystylus* spp. timber and products: applied research meeting CITES enforcement needs. *Endangered Species Research*, 9(3), 255-261.
- Perry, A. L., Lunn, K. E., & Vincent, A. C. (2010). Fisheries, large-scale trade, and conservation of seahorses in Malaysia and Thailand. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 20(4), 464-475.
- Petrosian, G. A., Pires, S. F., & van Uhm, D. P. (2016). An overview of seized illegal wildlife entering the United States. *Global Crime*, 17(2), 181-201.
- Raj, P., Saini, K., & Surianarayanan, C. (Eds.). (2020). *Blockchain technology and applications*. CRC Press.
- Raja, P., R., A., K. (2024). Trade of Endangered Animals in India and its Critical Analysis. *International Journal for Research in Applied Science and Engineering Technology*, doi: 10.22214/ijraset.2024.60065
- Ramadanti, N. A., Tahamata, L. C. O., & Leatemia, W. (2023). Perdagangan Satwa Liar Ditinjau Dari Convention On International Trade In Endangered Species Of Wild Fauna And Flora. *TATOHI: Jurnal Ilmu Hukum*, 3(4), 385-393.
- Rios, J. (2024). An Examination of the Ways in Which Transdisciplinary Research Could Be Used to Incentivize Local Communities to Combat the Illegal Wildlife Trade. *FIU Undergraduate Research Journal*, 2(1), 11.

- Sazdovska, M. M. S. M., Nikoloska, S., & Sviderski, M. (2022). THE ROLE OF CUSTOMS IN COMBATING ENVIRONMENTAL CRIME. *Horizons-International Scientific Journal*, 31(2), 26-42.
- Shen, L., Zhang, Z., Zhou, Y., & Xu, Y. (2023). Applying blockchain technology and the internet of things to improve the data reliability for livestock insurance. *Sensors*, 23(14), 6290.
- Sirait, R. A., Damayanti, T., Hidayat, D. R., & Prastowo, F. A. A. (2018, November). Digital intelligence strategy in combatting wildlife trafficking. In *Journal of Physics: Conference Series* (Vol. 1114, No. 1, p. 012091). IOP Publishing.
- Song, T., Luo, Z., Huang, Y., Li, Y., Fang, L., & Chang, J. (2023). A data set of the crackdown on cross-border wildlife crimes in China, 2014–2020.
- Stephen, C., Carmo, L. P., las Nieves Montano Valle, D. D., Friker, B., Sousa, F. M., Vidondo, B., & Berezowski, J. (2022). The implementation gap in emerging disease risk management in the wildlife trade. *The Journal of Wildlife Diseases*, 58(4), 705-715.
- Tambi, M. R., Zolkipli, A. M., & Salehuddin, A. M. (2023). A Study of the Causal Factors of Animal Crimes in Malaysia. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 8(8), e002445-e002445.
- Tarmizi, N. M., & Rizwan, N. I. (2024). Integrated Supervised Classification of LULC in Identifying Musang King Durian Illegal Farming Location. *Jurnal Sylva Lestari*, 12(2), 459-479.
- Tokkozhina, U., Martins, A. L., Ferreira, J. C., & Casaca, A. (2022, December). Traceable Distribution of Fish Products: State of the Art of Blockchain Technology Applications to Fish Supply Chains. In *International Conference on Intelligent Transport Systems* (pp. 89-100). Cham: Springer Nature Switzerland.
- TRAFFIC. (2013, September 9). Customs Department and TRAFFIC set a course to fight illegal ivory trade. Retrieved from the TRAFFIC organization website: <https://www.traffic.org/news/customs-department-and-traffic-set-a-course-to-fight-illegal-ivory-trade/>.
- United Nations. (2017, November 7). Criminal justice response to wildlife crime in Malaysia Retrieved from the United Nations website: <https://www.unodc.org/roseap//en/2017/1/wildlife-crime-malaysia/story.html>.
- Wardono, S., Alkadrie, S. I. T., Wibowo, A. S., Reksajaya, A. S., Wibowo, W., & Aries, G. (2022). Pengaturan Pemanfaatan Perdagangan Jenis Ikan Dilindungi/Appendiks Cites Di Wilayah Kerja Lpspl Serang. *Jurnal Teknologi Perikanan dan Kelautan*, 13(2), 231-237.
- Weissgold, B. J. (2024). US wildlife trade data lack quality control necessary for accurate scientific interpretation and policy application. *Conservation Letters*, 17(2), e13005.
- Wich, S. A., & Koh, L. P. (2018). *Conservation drones: mapping and monitoring biodiversity*. Oxford University Press.
- William, N. K. (2018). *Effects of Technology on Customs Performance at The Port Of Mombasa* (Doctoral Dissertation, Jomo Kenyatta University Of Agriculture And Technology).
- Zakuan, Z. Z. M., Hassan, S. A., & Mahmood, A. (2023). Illegal Medical Product and Deferred Prosecution Agreement in Malaysia. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 8(2), e002145-e002145.
- Zhang, Y., Liu, Y., Jiong, Z., Zhang, X., Li, B., & Chen, E. (2021). Development and assessment of blockchain-IoT-based traceability system for frozen aquatic product. *Journal of Food Process Engineering*, 44(5), e13669.

This article is licensed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (<http://creativecommons.org/licenses/by-nc-sa/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. Any derivative works must be distributed under the same license as the original.

