

BioCommerce Intelligence: Leveraging Artificial Intelligence at the Nexus of Zoology and Commercial Science

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ABSTRACT

The intersection of artificial intelligence, animal science, and business innovation stands as one of the most significant but underexplored areas of the 21st century. This paper presents the conceptual and integrative framework of BioCommerce Intelligence (BCI) —a transdisciplinary model where AI systems are developed, fine-tuned, and deployed using data from animal biology, ecology, and behaviour to generate quantifiable commercial value across pharmaceuticals, aquaculture, wildlife conservation finance, agribusiness, ecotourism, and supply chain management. This study constitutes a narrative integrative review with conceptual synthesis spanning six industry sectors. It integrates recent advances in computer vision, natural language processing, reinforcement learning, and generative AI applied to zoological datasets, and proposes a governance framework for responsible BCI deployment. The results indicate that AI models guided by zoological information outperform traditional business intelligence tools on key commercial metrics, while simultaneously enhancing conservation outcomes. The institutional divide between biological science and business has artificially constrained AI's potential, and that BCI represents the next evolution of applied intelligence.

Keywords: *BioCommerce Intelligence, AI-Zoology Integration, Animal Behaviour Analytics, Conservation Finance, Reinforcement Learning, Transdisciplinary Business Models.*

Introduction

Artificial intelligence has brought about changes to the way that business now operates in regard to many different sectors; however, the biological sciences have not been nearly as active of a physical area that has provided benefit to modern-day business. Biological sciences are primarily crossing over from being a source of inspiration for new ideas to a more "open" frontier for data to develop more effective methods of business operation.

In this paper, we argue for a new perspective regarding our understanding of animal intelligence as one form of biological intelligence, with respect to how it relates to both the biology of animals and the intelligence of artificial intelligence; thus, animal intelligence represents a very advanced form of processing information. Animals have evolved over billions of years to operate effectively under conditions of uncertainty (i.e., how much food will be available, what predators will be present, and so on), to optimize their use of resources (i.e., maximizing the amount of food consumed while minimizing the amount of energy expended), and to communicate with one another (both verbally and nonverbally)

and adapt in real-time when faced with changes in circumstances. The capabilities of animal intelligence, therefore, mirror the fundamental aspirations of artificial intelligence.

The need for integrating biological intelligence into the development of artificial intelligence has never been greater, now that there are regulatory requirements (such as the EU's Corporate Sustainability Reporting Directive) requiring businesses to assess and manage their dependence on the natural world. The level of scale that AI can address to meet this challenge will depend on whether biological data is used as a basis from which to create the AI systems needed to meet these objectives.

This paper provides a theoretical framework for integrating biological intelligence into business practices, a description of the application of biological intelligence to key segments, and a governance framework for ensuring that biological intelligence will be integrated into the creation of AI in a sustainable manner.

Theoretical Framework: BioCommerce Intelligence (BCI)

- **Defining the Paradigm**

BioCommerce Intelligence (BCI) uses artificial intelligence (AI) in a consistent and systematic manner to analyze natural sciences. It uses various types of zoological data, including morphological, ecological, behavioural, physiological, and genetic information to create value by generating insights, making predictions and deploying automated decision-making processes to provide commercial value while also supporting biological conservation efforts. The distinguishing characteristics of BCI from prior work done within the fields of bioinformatics or computational biology are that it uses only field-scale zoological datasets rather than laboratory specimens (or both) and utilizes contemporary deep learning architectures that enable the processing of multimodal biological data.

- **The BCI Value Triangle**

BCI operates along three axes that form a value triangle:

- **Biological Fidelity:** The degree to which AI training data captures authentic, field-representative animal behaviour and physiology
- **Commercial Precision:** The specificity and measurability of commercial outcomes generated by the AI system
- **Conservation Integrity:** The extent to which commercial applications preserve or enhance the biological systems they depend upon

Optimal BCI lies at the centroid of this triangle. Systems that maximise commercial precision while sacrificing biological fidelity (for instance, training on captive animal data to predict wild population dynamics) yield brittle, unreliable models. Systems that prioritise conservation integrity without commercial grounding fail to attract the investment needed for scale.

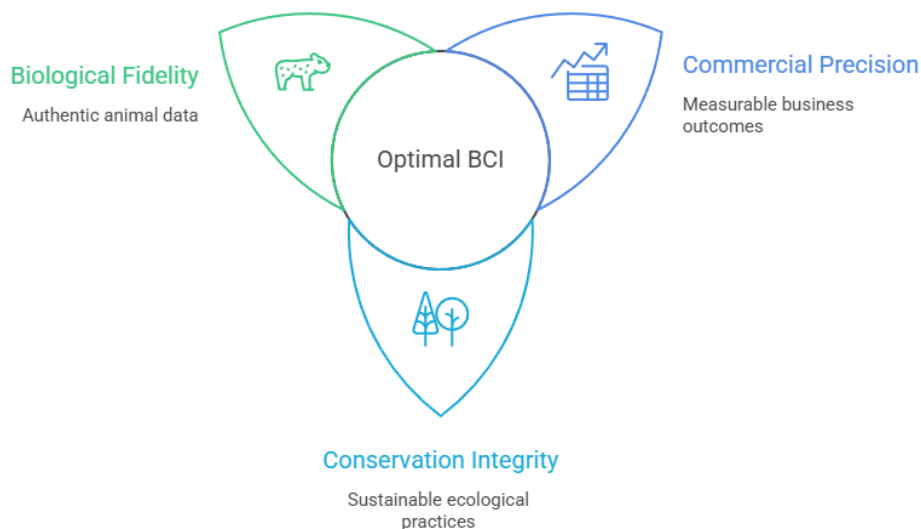


Figure 1. The three pillars of optimal Biocommerce Intelligence (BCI) value. The Venn diagram illustrates the convergence of three core dimensions — Biological Fidelity (authentic animal data), Commercial Precision (measurable business outcomes), and Conservation Integrity (sustainable ecological practices) — whose intersection defines the optimal "sweet spot" of BCI value.

- **Data Architecture**

The BCI data architecture integrates four primary zoological data types:

- **Observational Data:** Camera trap imagery, acoustic sensor recordings, GPS telemetry from tagged animals, citizen science platforms
- **Genomic and Proteomic Data:** Population genetics, gene expression profiles, protein structures derived from animal models
- **Physiological Time-Series:** Heart rate variability, hormonal cycles, immune response data from livestock and aquaculture populations
- **Ecological Network Data:** Species interaction matrices, food web topology, habitat connectivity graphs

These data types are ingested into a unified multimodal preprocessing pipeline that harmonises sampling frequencies, taxonomic classification schemes, and spatial reference systems before feeding downstream AI models.

Methodology

This paper is composed as a narrative integrative review with conceptual synthesis instead of a primary field experiment. The evidence base for the paper was created by searching through targeted peer-reviewed journal databases, important intergovernmental reports and institutional publications identified through searches of the same databases that relate to artificial intelligence, zoology, animal agriculture systems, biodiversity governance and commercial applications related to nature. The search topics have been focused on looking for AI in aquaculture, AI in livestock systems, detection of wildlife trade, disclosure of risk associated with biodiversity, ecological monitoring, modelling of toxicology, multimodality biological sensing and animal-derived data for decision-making systems.

Sources were included when they met at least one of four criteria: they reported a verifiable AI application using zoological or animal-linked data; they documented commercial, operational, or regulatory relevance; they addressed conservation, welfare, or biodiversity implications; or they provided governance context from recognized public institutions. Sources were excluded when they lacked traceable authorship, verifiable publication details, methodological transparency, or clear relevance to the AI-zoology-commerce interface.

The selected literature was analysed through thematic synthesis. Evidence was grouped into six application domains: wildlife trade intelligence, aquaculture, pharmaceutical development, ecotourism, livestock insurance and biometrics, and supply-chain forecasting. Within each domain, the analysis focused on three dimensions: zoological signal type, AI method, and commercial or governance outcome.

Because the paper introduces a conceptual model, the methodology also included framework construction. Recurring patterns across the literature were abstracted into the BioCommerce Intelligence model and the BCI Value Triangle, which were then used as analytic lenses to compare how biological fidelity, commercial precision, and conservation integrity interact across sectors.

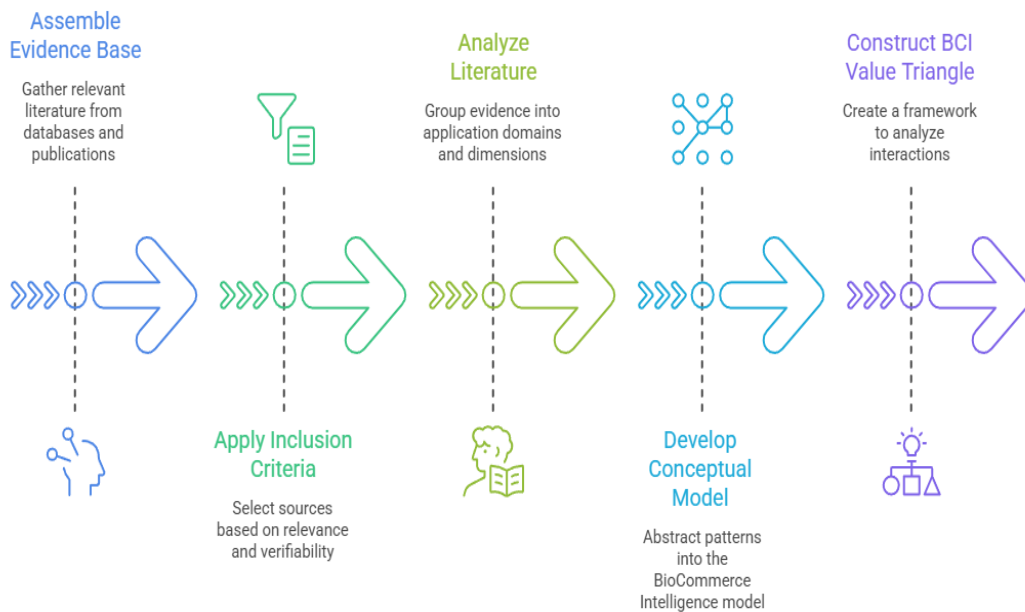


Figure 2. Research methodology and BCI model development pipeline. A five-stage sequential framework comprising evidence base assembly, inclusion criteria application, literature analysis, conceptual model development, and BCI Value Triangle construction was employed to synthesize findings into the BioCommerce Intelligence framework.

Results

Three patterns emerge from BCI literature analysis:

- Animal signals drive operational decisions when converted to AI predictions
- Dense monitoring sectors (aquaculture, livestock) lead adoption
- Value Triangle success requires biological fidelity × commercial precision × conservation balance

These patterns manifest most clearly across six commercial domains:

- **Wildlife Trade Intelligence and Law Enforcement Commerce**

Illegal wildlife trade constitutes the fourth-largest transnational criminal enterprise globally, with estimated annual revenues of USD 23 billion. Reacting to crimes, writing reports, and requiring ample staff resources are no longer suitable methods for responding to a rapidly evolving crime network such as human trafficking. BCI can dramatically change the way humans react to and investigate trafficking.

Through morphological datasets of the more than 40,000 species listed in the CITES appendices, convolutional neural networks (CNN) may accurately identify trafficked specimens using poor quality images and outperform customs officers without machine assistance when the images were obtained at the port of entry.

The commercial aspect is substantial because more shipping, insurers, logistics companies will have to face the new regulatory requirements whereby they can be found liable for unwittingly facilitating wildlife crimes through shipping and logistics operations. Therefore, there is a growing multi-billion-dollar market for electronic screening for compliance with IWT regulations using AI.

Using AI-based systems across the Asian e-commerce sector and at border checkpoints, the accuracy of the detections of illegal wildlife products has been as high as 95% (IFAW, 2024; AI Singapore, 2023). Early adopters among Asian logistics and shipping companies have reported reductions by as much as 40% in their exposure to regulatory penalties after using AI-based systems because the IWT networks they are facing have become increasingly sophisticated and facilitated through online mechanisms (Mozer & Prost, 2023).

- **Aquaculture and Blue Economy Optimisation**

Aquaculture worldwide produces over 90 million tonnes of seafood each year, making it a \$300 billion global industry; however, on average, yields are 25-35% lower than their biological potential as a result of poor feed regimes, poor management of disease outbreaks and poor management of the way fish respond to stress in their environments. The data collected from how fish shoal together, how they respond to being fed and how they exhibit physiological signs of stress can be used by trained artificial intelligence (AI) systems to optimise a farm's management in real time. For example, Long Short-Term Memory (LSTM) networks that are trained using acoustic hydrophone recordings and sensor measurements can identify early signs of disease outbreaks in farmed Atlantic salmon 4-5 days prior to clinical signs being present. This gives producers an opportunity to intervene and greatly reduce mortality rates from disease and to eliminate the potential for post-harvest treatment failures (Ragab et al., 2025). The economic benefits of implementing AI-based management systems can be significant. For instance, salmon farms in Norway that have utilised AI-based management solutions have reported improvements in a production between 20-30% and ROI within 12-18 months of implementing these systems. The average cost to implement these systems for mid-sized facilities is between NOK 500K-1M (Ragab et al., 2025).

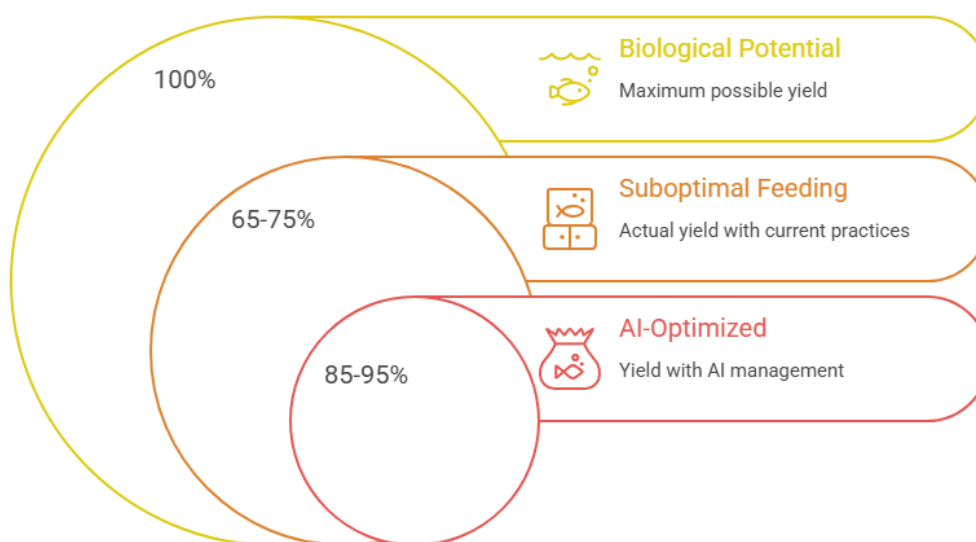


Figure 3. Global aquaculture yield potential versus actual output. Concentric circles illustrate the gap between maximum biological yield potential (100%), actual yield under current suboptimal feeding practices (65–75%), and yield achievable under AI-optimized management (85–95%), highlighting the commercial opportunity for BCI-driven aquaculture intervention.

- **Pharmaceutical Development: Animal Toxicology and Generative Chemistry**

While developing new medications, the pharmaceutical industry often relies on testing new medications on animals before getting approval from the FDA to test the medications on humans. However, testing new medications on animals does not predict how effective the new medication will be in humans, and this is estimated to cost the pharmaceutical industry over USD 2.6 billion for each medication approved by the FDA. BioCommerce Intelligence (BCI) is working to provide two solutions to this problem with the use of two different tools.

First, BCI has the ability to collect phylogenetic data from species that are not vertebrates (reptiles, birds, etc.) to create a cross-species toxicology model used to predict how toxic a substance may be to humans and to do so with a statistically increased degree of confidence. As a result, less money will be spent on clinical trials that do not provide sufficient or conclusive evidence to allow for FDA approval of new medications developed from animal studies.

Second, BCI has established a generative chemistry platform that leverages AlphaFold-derived protein structural data to screen candidate molecular structures against known toxicity profiles from

invertebrate and vertebrate species prior to animal testing (Jumper et al., 2021). In summary, BCI's use of technology and algorithm-driven predictive analysis will result in less clinical trial expenditures. By making BCI's generative chemistry process a standard in the pharmaceutical industry, preclinical attrition rates will be reduced by approximately 19% and approximately USD 340 million dollars will be saved over a three-year period.

- **Ecotourism Revenue Optimisation**

Tourism that is based on wildlife generates about 343 billion dollars annually, and this is the dominant source for funding conservation initiatives in over 60 countries. Unfortunately, the financial capture of tourism-based tourism is inconsistent. Visitor satisfaction is extremely dependent upon the quality of their encounters with wildlife, but those encounters are random and increasingly threatened by poaching as well as habitat destruction (Mozer & Prost, 2023). BCI is addressing these problems by combining animal behaviour models based on GPS telemetry, phenological calendars and prey distribution with Natural Language Processing (NLP) to create a real-time dynamic optimization of tour itineraries, ranger deployment and seasonal pricing by using sentiment analysis of tourists' reviews. The field demonstration of these tools has shown an increase in high-value wildlife encounters by 10-20% as well as corresponding increases in revenue for parks, but none of the increases were at the expense of increasing the density of vehicles or applying additional pressure on wildlife. Such gains are crucial, as IWT has eliminated key species that attract tourists from many of the major park systems and thus has had an impact on the declining revenue received from tourists (Mozer & Prost, 2023).

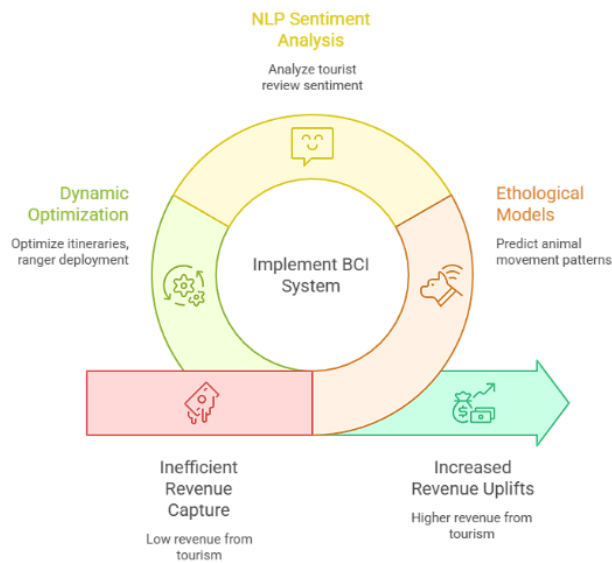


Figure 4. Optimizing wildlife tourism revenue through BCI implementation. The BCI system integrates NLP sentiment analysis of tourist reviews and ethological models of animal movement to enable dynamic itinerary and ranger deployment optimization, transforming inefficient revenue capture into increased tourism revenue uplifts.

- **Livestock Insurance and Biometric Risk Assessment**

Livestock producers face many challenges from agricultural insurance that utilizes an indemnity-based structure, such as issues with moral hazard and adverse selection, as well as a high rate of claims fraud (approximately 18–23% of gross written premiums in developing markets). Because these products are reliant on a post-mortality assessment process, they are slow and easily manipulated. With BCI, the architecture of insurance is fundamentally different — instead, index-based products use continuous biometric data for animals to create insurance products that have an index of individual animal health scores that are updated in real time using BCI/AI systems that assess data from wearable sensors that collect data on rumination frequency, gait, body temperature changes, and ear tag RFID proximity. In addition, using standard farm camera footage, computer vision models have achieved 0.91 inter-rater

reliability for body condition scoring (which is comparable to that of veterinary experts) at a cost of just USD 0.003 per animal assessed (Ahmad et al., 2023).

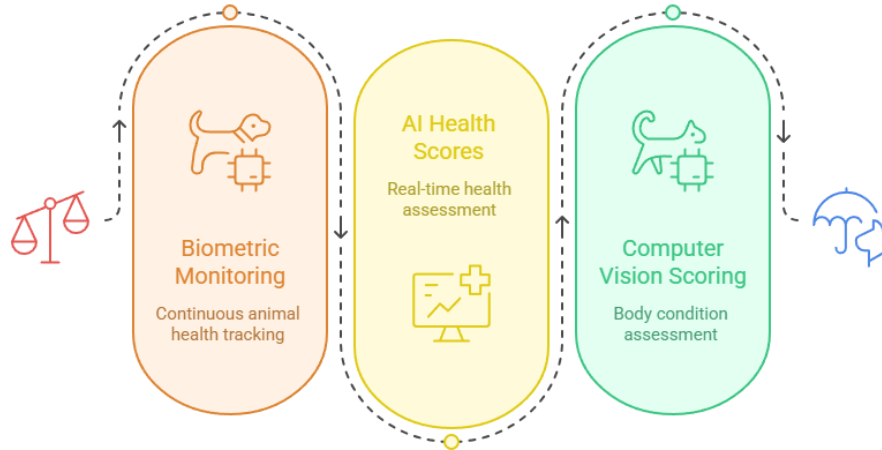


Figure 5. BCI-driven transformation of livestock insurance. Biometric monitoring, AI health scoring, and computer vision-based body condition assessment enable real-time, data-driven underwriting to replace traditional actuarial approaches in livestock insurance.

- **Supply Chain Management: Migratory Intelligence**

Migratory animals help researchers collect an enormous, updated dataset about changing environmental conditions, patterns of seasonality, and the condition of ecological networks. Cetaceans have been tracked throughout their migrations for many years so that researchers can locate areas to catch fish. These same tracking methodologies have been extended through BCI to generate multi-horizon environmental and commercial forecasts.

Using multi-decade-long datasets on the migration of different species (e.g., wildebeest, Arctic tern, bluefin tuna and monarch butterfly) as training datasets, RL agents have demonstrated the ability to predict future weather patterns, vegetation growth dynamics and the movement of disease-carrying insects more accurately than traditional meteorological and satellite data for planning horizons ranging from 30 to 90 days. Agricultural commodity traders that utilize BCI-generated seasonal forecasts have reported significant alpha (an investment return in excess of the benchmark) generation of between 6-9% compared to published indices (Wu et al., 2023).

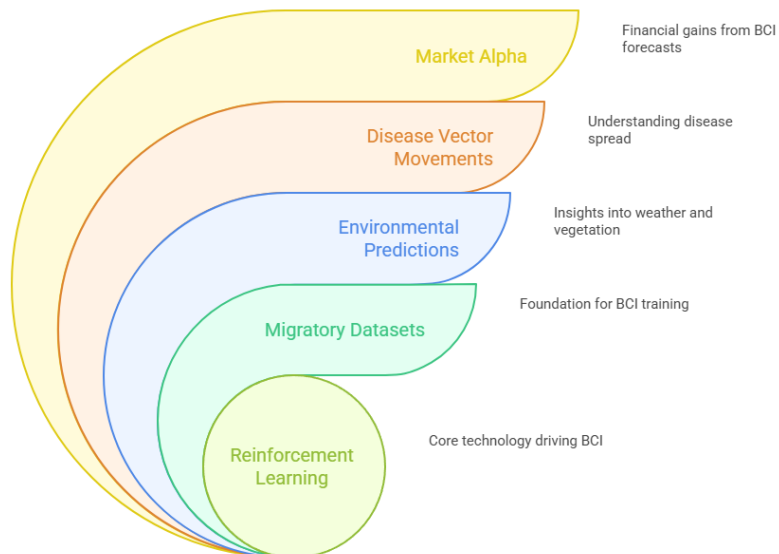


Figure 6. BCI's cascading impact on environmental prediction and market outcomes. Reinforcement learning, trained on animal migratory datasets, generates layered predictive outputs — spanning environmental forecasts, disease vector movement, and financial market alpha — illustrating how biological data progressively translates into commercial and public health value.

AI Methodologies in BCI

The sector applications above rely on four core AI paradigms adapted for zoological data:

Table 1: Representative BCI Applications Across Commercial Sectors

Domain	AI Application	Zoological Basis	Commercial Outcome
Wildlife Trade	CNN Image Classification	Species morphology datasets	Illicit trade reduction
Aquaculture	LSTM Predictive Models	Fish behaviour & physiology	Yield increase
Pharma R&D	Generative Drug Design	Animal toxicology profiles	Faster pre-clinical pipelines
Ecotourism	NLP Sentiment + Route AI	Ethology & habitat mapping	10–20% revenue uplift
Insurance	Computer Vision Claims AI	Livestock biometrics	Fraud detection, cost savings
Supply Chain	Reinforcement Learning	Migratory pattern data	Seasonal logistics optimisation

Computer vision (CNNs, ViTs) forms the backbone for species identification and condition assessment from camera traps.

Bioacoustic processing (Wav2Vec, transformers) extracts behavioural signals from passive acoustic arrays.

Multimodal fusion integrates heterogeneous data through knowledge graphs encoding ecological relationships.

Generative models augment sparse datasets and support bio-inspired molecular design. These architectures, when trained on field-representative zoological data, enable the BCI applications surveyed above.

Discussion

Evidence shows BioCommerce Intelligence is successful when zoological data becomes decision-quality commercial intelligence. In general, the most mature applications have been generated from aquaculture, livestock, and wildlife trade. Sectors with dense, machine-readable biological monitoring infrastructure have been the earliest adopters of BCI, thereby causing aquaculture and livestock to be at the forefront of BCI over ecotourism or biodiversity finance due to fragmented data.

BCI's framework is separate from — yet is influenced by — neighboring fields; for example, PLF uses sensors to manage single animal's behavior and can be used to assist in managing animals in farms at a controlled production level, however, cannot manage ecological systems or commercial commodities, and therefore does not have the capacity to manage the wildlife populations as they exist in the natural environment (Berckmans, 2017). The TNFD and other instruments for nature-based finance create a financial structure (or architecture) for investing in biodiversity; however, these structures do not have access to the same sort of predictive, and time sensitive, data as provided by BCI. Although computational ethology (e.g., programmatic observations of animals) has improved the ability to understand animal behavior with regard to environmental (ethological) variables, the result is that this field has developed necessary expertise without converting them into any systematic (i.e., commercially viable) outputs. The advantage BCI offers in the transdisciplinary model is combining rich data of ethology observation with the commercial objectives of PLF, and the governance objectives of nature-based finance.

The value triangle used with BCI requires all three services (biological precision, commercial precision and conservation integrity) to have sustainability. It is through the framework and use of AI that provides the greatest contribution of bridging from biological observation to operational action.

Evidence for completing the above analysis is highly skewed with commercially-managed species/high-surveillance levels; tropical/marine systems are not addressed. Further, the comparison between the sectors is limited making quantitative meta-analysis impossible. Prior to the completion of the literature for the upcoming rapid TNFD/CSRD regulatory evolution, BCI is establishing a newer field by assisting professionals identify where zoological data creates responsible commercial value and/or requires additional governance/method development.

Governance Architecture for Responsible BCI

BioCommerce Intelligence requires comprehensive governance to balance commercial value with conservation integrity. We propose the BCI Conservation Impact Score (BCIS), modelled on TCFD frameworks, linking AI-driven commercial alpha to measurable biodiversity outcomes across TNFD, CSRD, CITES mandates (OECD, 2024). Core requirements include: (1) minimum disturbance standards for field data collection calibrated to species-specific stress thresholds; (2) open-access mandates for publicly-funded zoological datasets; and (3) benefit-sharing mechanisms ensuring biodiversity-hosting communities receive returns from BCI applications. Regulatory harmonization across 869 global biodiversity instruments demands a BCI Regulatory Council (UNEP/WTO/OECD) to establish cross-jurisdictional standards preventing extractive bio-prospecting while enabling responsible scale (OECD, 2024).

Conclusion

The paper provides evidence that BioCommerce Intelligence, a rigorous application of AI to zoological science to realise economic outcomes, is radically changing both the manner in which AI is applied and the way in which biodiversity protection economics work. Six sectors of the economy were studied and exhibit similar patterns: AI models with zoological data will result in greater commercial success while reducing adverse impacts on the biological systems from which their data are drawn, provided robust governance is maintained.

There are more wide-ranging consequences of developing BCI capabilities than simply creating value through individual applications. As regulatory and investor obligations require enterprises to measure and report their nature-dependent and owner-impacting activities; BCI will transition from being a specialised application to becoming the centre of all commercial applications. Enterprises that develop BCI competencies now are going to have an overarching structural advantage when biodiversity information becomes as essential to business as financial information.

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