Biodiversity Risk Management in the Pharmaceutical Industry: A Comparative Study of the U.S. and China Pharmaceutical Companies

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Spring 2025

Abstract

Biodiversity loss poses escalating risks to industries reliant on natural resources, particularly pharmaceuticals. This comparative study examines how leading U.S. (Johnson & Johnson, Eli Lilly, Pfizer, Amgen) and Chinese (Jiangsu Hengrui, BeiGene, WuXi AppTec, Yangtze River Pharmaceutical Group) pharmaceutical companies manage biodiversity-related risks. Through textual analysis of sustainability disclosures, regulatory filings, and academic literature, the research reveals divergent strategies shaped by regulatory frameworks, market incentives, and global integration. U.S. firms employ comprehensive, globally aligned approaches, integrating biodiversity risk management across supply chains and adhering to international standards like the Nagoya Protocol. In contrast, Chinese companies prioritize localized operational improvements, driven by evolving national policies such as China's Biodiversity Conservation Strategy (2023–2030). While U.S. firms lead in transparency and innovation, Chinese firms demonstrate rapid compliance with domestic regulations but lag in holistic, cross-border strategies. The findings underscore the urgent need for industry-wide collaboration, standardized reporting, and policies that balance biodiversity conservation with economic growth in both regions.

Introduction

Biodiversity Loss

The loss of biodiversity is escalating at an alarming rate, with the global rate of species extinction now estimated to be 1,000-10,000 times greater than the natural baseline, a situation that has been intensifying over recent decades (WWF, n.d.). This biodiversity crisis is not only an environmental issue but is also deeply connected to economic risks, as biodiversity plays a crucial role in the provision of ecosystem services essential for economic activities. Biodiversity supports critical ecosystem functions such as pollination, water purification, and climate regulation, all of which are integral to sectors like agriculture, pharmaceuticals, and forestry. The degradation of biodiversity can thus undermine the productivity and stability of these industries (Giglio et al., 2024). For example, biodiversity loss can disrupt supply chains, increase costs for industries dependent on natural resources, and reduce the availability of raw materials for drug discovery and manufacturing in sectors like pharmaceuticals (Giglio et al., 2024; Costanza et al., 1997). Furthermore, biodiversity loss can lead to increased risks from climate change, such as the destruction of carbon sinks or reduced capacity for disaster mitigation, thus compounding the economic impact (OECD, 2019). In addition to the physical risks of biodiversity loss, industries are also facing transition risks from regulatory measures aimed at preserving biodiversity. These can include stricter land-use regulations, conservation efforts, and sustainability mandates, which may affect the operational costs and market behavior of firms (Giglio et al., 2024). As global attention shifts toward addressing these dual risks, it is becoming increasingly clear that biodiversity loss poses a substantial multifaceted threat to economic stability across multiple industries.

Relevance to the Pharmaceutical Industry

The pharmaceutical industry has a profound relationship with biodiversity, both as a consumer of biological resources and as a contributor to environmental degradation. Biodiversity is vital to the pharmaceutical sector, as many medicines are derived from natural compounds found in plants, animals, and microorganisms. The discovery of these compounds relies on the availability of diverse biological resources, making biodiversity an essential element for innovation in drug development (Mace et al., 2012). However, the industry's operations can also lead to significant environmental harm. Pharmaceutical manufacturing often results in pollution, including the contamination of water systems with pharmaceutical residues, which can disrupt aquatic ecosystems and threaten biodiversity (Néstor et al., 2017). For instance, antibiotic residues have been detected in rivers near manufacturing hubs, leading to antibiotic resistance in local bacteria and harming aquatic species (Akhter et al., 2024). Additionally, the extraction of natural resources for drug production can lead to habitat destruction and the overharvesting of medicinal plants, thereby contributing to biodiversity loss (Schippmann et al., 2002). Furthermore, the industry's dependency on ecosystem health is evident in its reliance on ecosystem services such as clean water, carbon sequestration, and pollination, which are integral to the production of raw materials for pharmaceutical goods (Giglio et al., 2024). Thus, the pharmaceutical sector's impact on biodiversity and its dependence on healthy ecosystems highlight the need for sustainable practices to mitigate the risks of biodiversity loss.

Research Purpose and Scope

The primary objective of this paper is to explore and compare how pharmaceutical companies in the United States and China address biodiversity-related risks. As biodiversity loss continues to escalate, industries increasingly recognize the economic implications of these risks, especially

sectors that rely on natural resources, such as the pharmaceutical industry. The study will analyze the risk management strategies employed by these companies to mitigate the negative impacts of biodiversity loss, with a focus on regulatory compliance, sustainable sourcing, and pollution control practices. The scope of this research is to provide a comparative analysis of the United States and China pharmaceutical companies, given the differing regulatory environments and ecological contexts in these two countries. By assessing how pharmaceutical firms in each country navigate biodiversity risks, this paper will provide insights into industry-specific approaches to biodiversity conservation and sustainability.

Methodology

Industry Selection

The pharmaceutical industry was selected for this study due to its significant interaction with biodiversity, both as a consumer of biological resources and as a contributor to environmental degradation. The sector relies heavily on the discovery of new drugs from natural sources, such as plants, animals, and microorganisms, many of which are integral to the development of treatments for diseases like cancer, diabetes, and infectious diseases. As a result, the depletion of these resources due to overharvesting, habitat destruction, and pollution presents substantial risks to the industry's ability to innovate and maintain its production pipeline. Furthermore, the pharmaceutical industry is responsible for substantial environmental impacts, including the contamination of water and soil with pharmaceutical residues, which can disrupt ecosystems and harm biodiversity. These dual relationships—both positive (dependence on biodiversity for drug development) and negative (pollution and resource depletion)—make the pharmaceutical sector an ideal focus for studying the intersection of biodiversity loss and economic activity.

Country Selection

The United States and China were chosen for this comparative study due to their different regulatory, economic, and environmental contexts. Both countries represent two of the largest pharmaceutical markets globally and are at the forefront of biodiversity conservation efforts. However, their approaches to biodiversity management are shaped by different political, economic, and regulatory environments, making them ideal for comparison.

In the U.S., the pharmaceutical industry operates within a well-established legal framework for environmental protection, with regulations such as the Endangered Species Act and the Clean Water Act directly impacting the industry's activities related to biodiversity. Furthermore, there is increasing corporate pressure for pharmaceutical companies to integrate sustainability and environmental stewardship into their business practices, driven by both regulatory mandates and consumer demand for responsible corporate behavior (Giglio et al., 2024).

In contrast, China, while also a major pharmaceutical producer, is a rapidly developing economy with an evolving regulatory framework for biodiversity protection. Over the past decade, China has significantly strengthened its environmental laws and policies, including the introduction of a Biodiversity Conservation Strategy and Action Plan 2023-2030. However, the enforcement of these regulations can be inconsistent due to the country's rapid industrialization and competing economic priorities. This makes China an interesting case for studying the balance between economic development and biodiversity conservation, especially in industries like pharmaceuticals that rely heavily on natural resources.

Company Selection

Three Chinese pharmaceutical companies (Jiangsu Hengrui Pharmaceuticals, BeiGene, WuXi AppTec, and Yangtze River Pharmaceutical Group) and three U.S. pharmaceutical companies

(Johnson & Johnson, Eli Lilly, Pfizer, and Amgen) have been selected for a comparison of their current approaches to managing biodiversity risks. These companies span a wide range of the pharmaceutical industry, each with diverse product portfolios and a global presence. Basic information about these companies can be found in the appendix.

Data Collection and Analysis

Data for this research are collected from a variety of sources, including industry reports, government publications, corporate sustainability disclosures, and academic literature. These reports will provide insights into how pharmaceutical companies in both the U.S. and China address biodiversity risks, including their policies on sustainable sourcing, waste management, and environmental impact reduction. Textual analyses will be used to analyze sustainability reports, focusing on keywords related to biodiversity conservation, risk management, and environmental practices. The analysis compared the scope, depth, and transparency of biodiversity risk management strategies. Limitations include variation in reporting standards.

Biodiversity Risks in the Pharmaceutical Industry

The pharmaceutical industry faces a range of biodiversity risks, both direct and indirect, due to its activities that depend on natural resources and contribute to environmental degradation. These risks include pollution, depletion of biological resources, habitat destruction, and species endangerment, all of which can significantly impact biodiversity and, in turn, disrupt the industry's operations. The following sections explore these risks in detail.

Direct Impacts

Pollution (Water, Air, GHG Emissions)

One of the most significant direct biodiversity risks from the pharmaceutical industry is pollution. Pharmaceutical manufacturing processes, including the production of active

pharmaceutical ingredients (APIs), generate significant pollution in the form of waste, chemical emissions, and pharmaceutical residues, which can have harmful effects on the surrounding ecosystems. For instance, pharmaceutical waste, if not properly treated, can end up in water systems, contaminating aquatic environments with active pharmaceutical ingredients (APIs) that are not removed during wastewater treatment (Daughton et al., 2011). These pollutants can accumulate in water bodies and affect aquatic organisms, including fish and amphibians, potentially disrupting reproductive systems, altering behavior, and reducing biodiversity in affected ecosystems (Carlsson et al., 2006). Air pollution is another concern. The pharmaceutical sector, like many other manufacturing industries, emits particulate matter and volatile organic compounds, which can contribute to air quality degradation and the formation of ground-level ozone, leading to respiratory problems in wildlife and negatively impacting plant and animal health (Sindhu et al., 2024). Additionally, the release of greenhouse gases (GHGs) from pharmaceutical production facilities contributes to global climate change, which in turn affects biodiversity by altering habitats and ecosystems on a global scale.

Depletion of Biological Resources

The pharmaceutical industry relies heavily on natural resources, particularly plants, animals, and microorganisms, for the development of new drugs. As a result, overharvesting of these biological resources poses a direct risk to biodiversity. For example, plants used in traditional medicines or for pharmaceutical research, such as Taxus contorta used in cancer treatment, face the threat of extinction due to overharvesting (Mulliken & Crofton, 2008). Similarly, animal species that are used for pharmaceutical research are at risk of population declines due to unsustainable exploitation (Cohen, 2007). The depletion of these resources could lead to the loss

of essential biological compounds, limiting the availability of raw materials for drug production and potentially hindering medical advancements.

Indirect Impacts

Habitat Degradation

Pharmaceutical manufacturing, especially in areas with rich biodiversity, can lead to habitat degradation. The construction and operation of pharmaceutical production facilities often require large amounts of land, which can result in deforestation, land degradation, and the destruction of ecosystems that are critical to maintaining biodiversity. In addition to direct land-use changes, the pollution from these facilities can further degrade the quality of nearby habitats, making them unsuitable for wildlife. In some cases, pharmaceutical companies may source raw materials from ecologically sensitive areas, contributing to further habitat loss. Unsustainable collection of medicinal plants, for instance, can lead to deforestation and the depletion of vital ecosystems, affecting not only the species used for drug discovery but also the broader ecosystem services that these habitats provide. The cumulative effects of habitat degradation from industrial activities can disrupt ecological balance and exacerbate biodiversity loss in the long term. Furthermore, when natural habitats are disrupted, humans and domestic animals are brought into closer contact with wildlife, creating new opportunities for pathogens to spill over from animals to humans. An example of this is the emergence of SARS-CoV-2, the virus responsible for COVID-19 (Lawler et al., 2021).

Species Endangerment

The depletion of biological resources and habitat degradation can indirectly lead to species endangerment. As pharmaceutical companies rely on natural sources for raw materials, many plant and animal species face the risk of becoming endangered or extinct. This risk is particularly

pronounced in biodiversity hotspots, such as tropical rainforests, which are rich in species that have not yet been fully explored for their potential pharmaceutical uses. Habitat destruction caused by pharmaceutical industry activities can lead to the fragmentation of ecosystems, isolating species and reducing their chances of survival.

Risk Management Approaches in the U.S. and China

U.S. Pharmaceutical Companies

When comparing the biodiversity risk management approaches of U.S. and Chinese pharmaceutical companies, several key differences and similarities arise, particularly in the scope and depth of their strategies. U.S.-based pharmaceutical companies, including Johnson & Johnson, Eli Lilly, Pfizer and Amgen, have developed more comprehensive, global biodiversity strategies that incorporate sustainability deeply into their corporate frameworks.

These companies are actively addressing biodiversity risks not only in their operations but also across their entire value chain, including manufacturing facilities, product sourcing, and supply chains. By adhering to international biodiversity frameworks such as the Convention on Biological Diversity and the Nagoya Protocol, these U.S. companies ensure that their operations align with global sustainability standards.

For instance, Johnson & Johnson has integrated biodiversity considerations into its supplier engagement practices, requiring suppliers to comply with its Responsibility Standards for Suppliers, which emphasize environmental sustainability and biodiversity protection. Similarly, Eli Lilly has reduced its dependence on natural resources through innovations like recombinant Factor C (rFC) testing, which conserves horseshoe crabs and the local ecosystems they support. Amgen stands out for its ambitious environmental sustainability commitments and governance structure supporting biodiversity objectives. The company's ESG Council, with executive-level

oversight, ensures biodiversity is considered in strategic decision-making. Amgen's initiatives include the Ecovation approach, which embeds sustainable design and operations into new facilities to minimize environmental footprints and directly protect nature and biodiversity. Amgen is also committed to advancing animal-free testing methods, such as replacing horseshoe crab-derived tests with non-animal alternatives, and actively engages with suppliers to identify and mitigate biodiversity risks throughout its value chain. The company's 2027 sustainability goals include achieving carbon neutrality, reducing water consumption by 40%, and cutting waste disposal by 75% from a 2019 baseline, with progress tracked through science-based targets and supplier engagement.

Despite these extensive initiatives, there remains room for improvement, particularly in terms of greater transparency and clear, measurable outcomes for their biodiversity efforts. Pfizer, for example, has implemented biodiversity risk assessments and initiated native biodiversity improvements at construction sites, but there is an opportunity for the company to broaden its focus beyond operational sites and integrate a comprehensive strategy across its global supply chain. Although U.S. pharmaceutical companies are making significant progress in biodiversity management, they could benefit from providing more detailed reports on their initiatives' impact and performance. By continuing to innovate and collaborate—both within the industry and with external stakeholders—these companies are well-positioned to lead in sustainable pharmaceutical practices and biodiversity conservation.

Chinese Pharmaceutical Companies

Chinese pharmaceutical companies, including Jiangsu Hengrui, BeiGene, WuXi AppTec, and Yangtze River Pharmaceutical Group, are at varying stages in developing and implementing biodiversity risk management strategies. While these companies increasingly acknowledge the

importance of biodiversity conservation, their efforts remain largely focused on local environmental initiatives, with a gradual shift toward more comprehensive approaches. Jiangsu Hengrui has taken notable steps toward promoting green operations within its factory grounds, such as planting lawns and shrubs, and ensuring ground permeability in parking lots to support local ecosystem diversity. However, these actions are primarily limited to the immediate surroundings of their facilities and do not extend to broader biodiversity risks across the company's global supply chain or raw material sourcing practices. BeiGene has introduced green chemistry principles in its production processes, which help mitigate some environmental impacts associated with chemical use, but there is little mention of any comprehensive biodiversity strategies beyond production. The company does not appear to engage in biodiversity risk assessments, supplier engagement, or actions to reduce the environmental impact of raw material sourcing. Similarly, WuXi AppTec has shown some innovation with its local biodiversity efforts, such as creating rain gardens at its Philadelphia site to improve local ecosystems and manage stormwater. Yet, WuXi AppTec's biodiversity efforts remain limited to specific locations, and there is little evidence that its strategy extends globally or addresses the potential ecological impacts of its drug discovery services. Yangtze River Pharmaceutical Group emphasizes the principle that "lucid waters and lush mountains are invaluable assets" and expresses a commitment to green development in its operations. Despite this environmental philosophy, public disclosures reveal limited concrete actions or measurable targets specifically related to biodiversity conservation. The company has not published detailed data on carbon emissions, biodiversity risk assessments, or specific conservation projects. Its environmental management appears to focus more on compliance and pollution control rather than proactive biodiversity protection.

Overall, while these leading Chinese pharmaceutical companies are making positive strides through individual projects and an increasing emphasis on environmental responsibility, most of their biodiversity efforts remain localized and do not yet encompass broader risks across their entire value chains. To strengthen their sustainability profiles, these companies would benefit from adopting more robust biodiversity risk assessments, engaging suppliers on biodiversity issues, and developing strategies that account for both local and global ecological impacts. Enhanced transparency and measurable outcomes will be key for these companies as they align with evolving regulatory expectations and global best practices in biodiversity conservation.

Factors Influencing Different Approaches in the U.S. and China

The divergent approaches to biodiversity risk management in the pharmaceutical industries of the United States and China are shaped by a complex interplay of regulatory, economic, political, and market forces. Below are the key factors driving these differences:

- Regulatory Frameworks and Enforcement
    - United States: The U.S. pharmaceutical industry operates within a robust and mature regulatory environment. Laws such as the Endangered Species Act and the Clean Water Act set clear standards for biodiversity protection and pollution control. U.S. regulatory agencies, notably the FDA and EPA, have well-established processes for monitoring compliance and enforcing environmental standards. Additionally, the U.S. is increasingly integrating biodiversity and sustainability criteria into corporate reporting and supply chain oversight, driven by both government mandates and market expectations.
    - China: China's regulatory framework for biodiversity is rapidly evolving. The recent launch of the National Biodiversity Conservation Strategy and Action Plan

(2023-2030) demonstrates a commitment to strengthening biodiversity governance, with specific targets and priority projects for conservation, mainstreaming, and sustainable use. However, enforcement can be inconsistent due to the scale of industrialization and regional disparities in regulatory capacity. While China has made significant financial investments in biodiversity (RMB 2.16 trillion from 2011 to 2020) (Wang, 2023), implementation at the local level can lag behind national policy ambitions.

- Economic and Market Incentives
    - United States: U.S. pharmaceutical companies are heavily influenced by investor and consumer demand for sustainability and transparency. ESG (Environmental, Social, and Governance) criteria are increasingly tied to access to capital and market competitiveness. Companies that demonstrate leadership in biodiversity risk management can benefit from reputational gains and preferential financing.
    - China: In China, state-driven incentives and policy directives play a larger role. Recent policy initiatives have promoted biodiversity financing, such as the issuance of biodiversity-themed green bonds and the development of ecological value accounting systems (Wang, 2023). These mechanisms are designed to attract private investment in conservation and encourage companies to align with national biodiversity goals. However, market-driven pressures for biodiversity transparency are generally less intense than in the U.S., though this is beginning to change as China's global market presence grows.
- Political and Strategic Priorities

    - United States: The U.S. increasingly frames biotechnology and pharmaceutical supply chains as matters of national security. Recent policy debates and legislative actions—such as the BIOSECURE Act (U.S. Congress, 2024)—reflect concerns about dependence on Chinese manufacturing and the need to safeguard domestic innovation and data. This has led to greater scrutiny of supply chain partners and a push for more resilient and transparent sourcing, including biodiversity considerations.
    - China: China's approach is shaped by a dual imperative: to maintain rapid economic growth and to address rising environmental concerns. The government's top-down directives encourage companies to adopt greener practices and invest in biodiversity, but economic development often remains the primary priority, especially in less developed regions. China's biotech sector also benefits from policy support for innovation and international collaboration, but with growing attention to data security and self-sufficiency.
- International Standards and Global Integration
    - United States: U.S. pharmaceutical companies are more likely to align with international biodiversity frameworks such as the Convention on Biological Diversity and the Nagoya Protocol. They often integrate global best practices into their operations and supply chains, partly due to their extensive international presence and stakeholder expectations.
    - China: Chinese firms are increasingly engaging with international standards, especially as they expand globally, but their primary focus remains on meeting domestic regulatory requirements and national policy targets. International

integration is growing, but the depth and breadth of biodiversity risk management across global supply chains are still developing.

- Transparency, Disclosure, and Public Awareness
    - United States: There is a higher degree of transparency and public reporting on biodiversity risks and management in the U.S. This is driven by regulatory requirements, investor expectations, and a culture of corporate accountability.
    - China: While disclosure is improving, Chinese companies generally provide less detailed public information on biodiversity risk management. Reporting is often driven by compliance with government mandates rather than voluntary transparency. However, new initiatives in biodiversity financing and ecological value accounting are expected to improve disclosure practices over time.

Conclusion

Biodiversity loss presents a profound and growing challenge for the pharmaceutical industry, threatening the very foundation of drug discovery and the sustainability of ecosystem. This comparative analysis of leading pharmaceutical companies in the United States and China reveals both encouraging progress and persistent gaps in biodiversity risk management.

U.S. pharmaceutical companies have developed more comprehensive and globally integrated approaches to biodiversity. Their strategies extend beyond compliance, embedding biodiversity considerations into supplier standards, operational targets, and innovation pipelines. These efforts are supported by mature regulatory frameworks, heightened stakeholder expectations, and a strong culture of transparency. While measurable progress is evident, further improvements in reporting and the consistent application of biodiversity metrics across all operations remain necessary. In contrast, Chinese pharmaceutical companies are advancing biodiversity initiatives

primarily at the local level. Their actions often focus on green operations, pollution control, and compliance with evolving national policies. However, these efforts are generally limited to facility grounds and do not yet fully address biodiversity risks throughout broader supply chains or raw material sourcing. As regulatory expectations and public awareness continue to rise in China, there is significant potential for these companies to expand their strategies and enhance transparency.

Ultimately, the findings underscore the importance of holistic, supply-chain-wide biodiversity risk management for the pharmaceutical sector in both countries. Moving forward, companies will need to strengthen biodiversity assessments, engage more actively with suppliers, and adopt measurable targets that reflect both local and global ecological impacts. Enhanced collaboration, innovation, and transparency will be essential as the industry aligns with global biodiversity conservation goals and responds to the increasing demands of regulators, investors, and society at large. By doing so, pharmaceutical companies can help secure the natural resources critical to their future and contribute meaningfully to the preservation of global biodiversity.

Appendix

Company	Headquarters	Market Cap (2024)	Markets Served	Stock Exchange (Ticker)
Jiangsu Hengrui Pharmaceuticals	Lianyungang, China	$50B USD	Primarily China, expanding globally	Shanghai Stock Exchange (SSE)
BeiGene	Beijing, China	$20B USD	Global (focus on U.S.)	NASDAQ (BGNE)
WuXi AppTec	Shanghai, China	$50B USD	Global	NYSE (WX)
Yangtze River Pharmaceutical Group	Taizhou, China	$20B USD (estimated)	China	Private
Johnson & Johnson	New Brunswick, USA	$500B USD	Global	NYSE (JNJ)
Eli Lilly	Indianapolis, USA	$700B USD	North America, expanding globally	NYSE (LLY)
Pfizer	New York City, USA	$200B USD	Global	NYSE (PFE)
Amgen	Thousand Oaks, USA	$140B USD	Global	NASDAQ (AMGN)

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