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Whitepaper:
The Singapore Manufacturing Sector and Biodiversity

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This whitepaper is part of a broader series of (academic and industry) papers on the topic of biodiversity impact of business operations, stemming from the collaboration between the Singapore Green Finance Centre and Impact Institute.

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Executive Summary

Southeast Asia is one of the world's most biodiverse regions, yet it is experiencing some of the highest rates of biodiversity loss globally. This decline poses not only ecological risks but also significant economic and social challenges, particularly for countries such as Singapore whose growth depends heavily on manufacturing and global value chains. As Singapore accelerates its transition towards advanced manufacturing, understanding and managing the biodiversity impacts associated with the sector has become increasingly critical. This white paper presents a biodiversity impact assessment of Singapore's manufacturing sector using the Global Impact Database – Biodiversity (GID Biodiversity). The analysis quantifies and monetises biodiversity impacts across the sector's full value chain, including upstream suppliers, direct operations, and downstream use of manufactured products.

The results show that Singapore's manufacturing sector generated an estimated 22 million PDF.ha.yr (Potentially Disappeared Faction of species per hectare per year) of biodiversity loss in 2024, equivalent to approximately US$80.7 billion in monetised impacts across the value chain. This implies that for every US$1 of manufacturing output produced across the value chain, approximately US$0.26 of biodiversity loss is generated. More than 95% of this impact arises from indirect value-chain activities, with downstream operations alone accounting for around 62% of total biodiversity loss. In comparison with the US$1.14 billion in monetised ecosystem service losses generated by the upstream value chain and direct operations of Singapore's electricity sector (for more details, please refer to the Whitepaper: The Singapore Electricity sector and biodiversity), the manufacturing sector generated approximately US$30.51 billion in monetised ecosystem services within the same value chains, highlighting the larger biodiversity footprint the manufacturing sector.

These findings have clear implications for policymakers and investors. By valuing and monetising the manufacturing sector's externalities on nature, this whitepaper aims to provide policymakers a tool to have a more integrated profit and loss perspective and focus on the social returns on investments. Existing policy instruments – such as the Energy Efficiency Grant – can be expanded or extended to drive wider adoption of low-carbon and resource-efficient practices across the manufacturing subsectors.

Taken together, this assessment demonstrates that biodiversity loss represents a material, quantifiable externality of Singapore's manufacturing sector. Integrating biodiversity considerations into industrial, energy, and financing policies will be essential to ensuring that Singapore's manufacturing growth remains economically resilient while aligning with national and regional sustainability objectives.

Introduction

Southeast Asia is one of the richest regions in terms of biodiversity on the planet, containing nearly 15% of the world's tropical forests by area (Stibig et al., 2014). Yet, at the same time, the region is also experiencing some of the highest rates of biodiversity and forests loss globally, with the highest proportion of vascular plant, reptile, bird and mammal species classified as globally threatened on the IUCN's Red List (Sodhi et al., 2010). Overexploitation of fisheries, pollution, invasive species, and climate change all contribute to the cumulative loss of ecosystems. The ASEAN Biodiversity Outlook (2023) notes that over 60% of assessed species in the region are now threatened or declining, while key ecosystem services such as water regulation, soil fertility, and coastal protection are deteriorating. Terrestrial and marine ecosystems across Southeast Asia are under severe stress, with growing implications for the region's economies and societies, which depend heavily on natural resource extraction, agricultural exports, and rapid urban development.

Southeast Asia's industries, from agriculture and forestry to energy and transport, depend on the very ecosystems that are deteriorating. The region's biodiversity loss is not only an ecological concern but also an economic and social one. The ability of our ecosystem to provide ecosystem services – which refer to the direct and indirect contributions of nature to human well-being such as food, materials, health, and livelihoods (Costanza et al., 1998) – is being increasingly challenged. Economically, biodiversity-related transition risks are increasingly causing material financial and business risks to daily operations. Transition risks can stem from policy, regulatory, or market changes as societies demand more sustainable business practices, all which may potentially strand assets in sectors such as fossil fuels, intensive agriculture, or infrastructure. Additionally, reputational risks – which may be considered a sub-category of transition risk – emerge when stakeholders hold companies accountable for harmful business operations. Together, these create a feedback loop in which risks to business operations and biodiversity loss reinforce each other, increasing both environmental and financial vulnerability. Understanding this connection is critical for the manufacturing sector in Singapore, which is the focus of this white paper.

Manufacturing, one of the key pillars of the Singapore economy, contributes around 19% of the country's GDP in 2023 (Economic Development Board - a, n.d.), with total manufacturing output in 2024 generating about US$316 billion for the local economy. The Singapore manufacturing sector comprises companies across various industries, ranging from medical technology to marine and aerospace. Figure 1 in the Methodology section details the proportion of the different subsectors within Singapore's manufacturing sector. Given the diversity of subsectors within the nation's manufacturing sector, it is expected that certain subsectors will have a more negative impact on biodiversity than others. For instance, the petroleum and coal products sector is likely to have a more severe impact on biodiversity, primarily because its entire lifecycle results in the complete disappearance of the product after combustion, unlike other subsectors such as transport equipment, where certain parts can be recycled at the end of their life. The wide footprint these industries have within Singapore's economy has undoubtedly contributed to carbon emissions and related climate externalities that stem from their operations. For example, when examining primary greenhouse gas emissions by sector, industry represented 49% of the nation's total emissions in 2022. In comparison, primary emissions from Singapore households represented only 0.9% of total greenhouse gas emissions in the same year (SingStat, 2024).

With a S$37 billion commitment from the Singapore government to the Research, Innovation and Enterprise 2030 initiative, Singapore aims to grow its manufacturing sector by 20% by 2030 under its Manufacturing 2030 initiative (Yap, 2025; Visit Singapore, n.d.). Hence, understanding the linkages between these industries and the environment in which they operate is essential to aligning climate mitigation policies with biodiversity protection policies in the country's pursuit of more advanced manufacturing.

Type and Principles of Analysis

This paper presents a biodiversity impact assessment of Singapore's manufacturing sector. The analysis aims to quantify and monetise the biodiversity impacts generated across key subsectors in the manufacturing sector in the Singapore economy through both direct (own operations) and indirect (upstream and downstream operations) impacts (for a detailed explanation of monetisation, please refer to explanation box 2).

The analysis uses the Global Impact Database Biodiversity to estimate both direct and indirect impacts at various stages of the manufacturing sector's value chain, expressed in footprinting and monetary terms.

The goal is to quantify and value the key drivers of biodiversity loss across different industries within Singapore's manufacturing sector and to provide recommendations to policymakers such as the Monetary Authority of Singapore, the Economic Development Board, and the Ministry of Trade and Industry for the decarbonisation and greening of the sector.

The analysis applies GID Biodiversity to map key industries' total output to sector-level environmental data. Biodiversity impacts are assessed across three parts of the value chain: upstream activities (suppliers and raw material production), direct operations (company-owned activities), and downstream activities (distribution, use, or disposal of products).

Each biodiversity impact driver is expressed in PDF.ha.yr (Potentially Disappeared Fraction of species per hectare per year). For more information, please refer to explanation box 1. These impacts are monetised through the estimated value of ecosystem services lost due to biodiversity degradation, using US$ impact as the functional unit of measurement (for more detail on monetisation, see explanation box 2). By combining biodiversity footprinting with monetary valuation, the approach translates environmental externalities into financial metrics.

Methodology

The biodiversity impact analysis used in this white paper was conducted using the Global Impact Database Biodiversity (hereafter GID Biodiversity), owned and managed by Impact Institute. GID Biodiversity applies a top-down country–sector analysis to quantitatively estimate impacts across countries and sectors in the global economy. Results cover both direct and indirect value-chain impacts. GID Biodiversity estimates these impacts using input–output analysis based on data on the interconnectedness of industries across countries, as well as their environmental and economic performance.

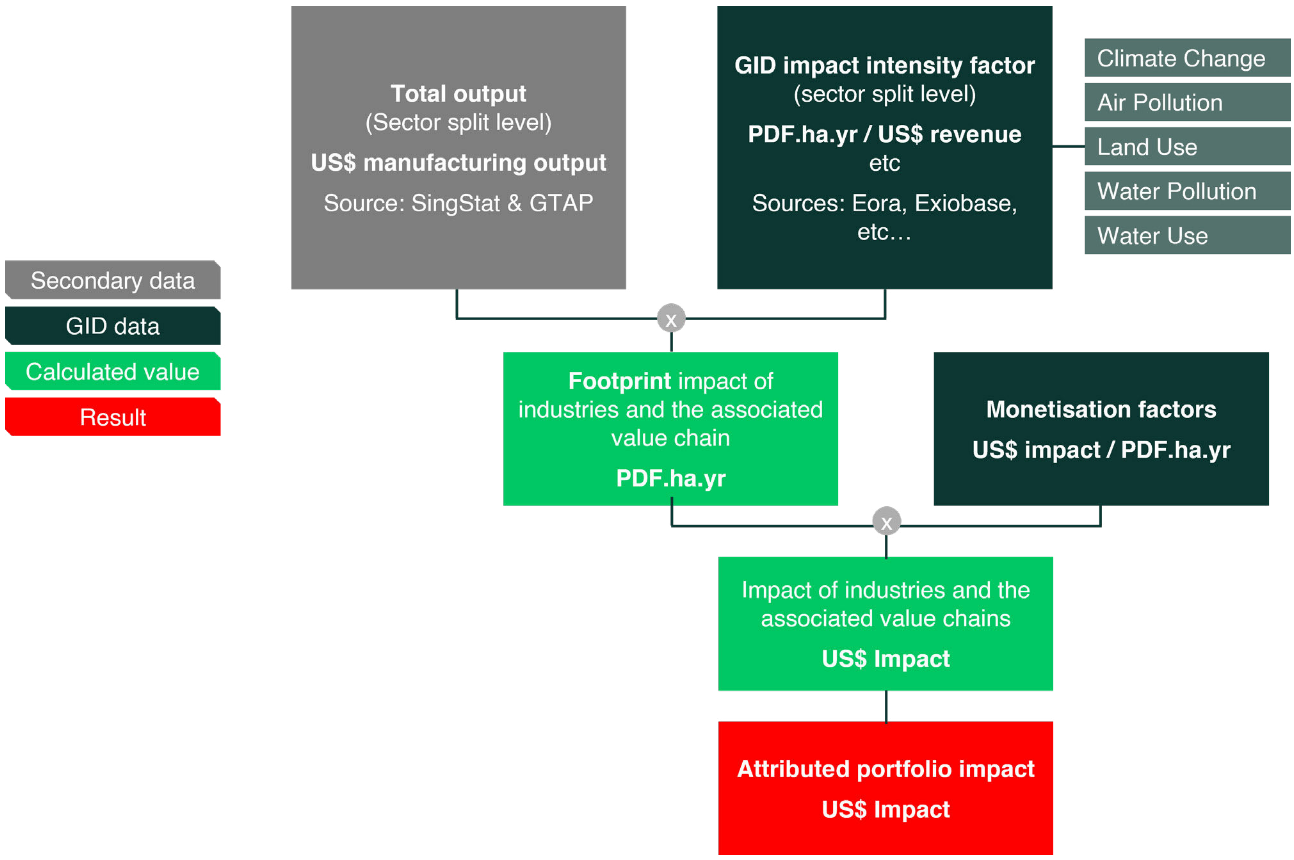
Five drivers of biodiversity impact are included in the analysis: land use, air pollution, climate change, water pollution, and water use. These drivers aggregate relevant indicators and are measured as either direct physical footprints on biodiversity or indirect biodiversity loss. These values are then converted into a footprint measure of ecosystem condition, namely PDF.ha.yr (see explanation box 1 for further details). All impact results are also presented in monetised terms, based on the value of ecosystem service losses associated with the original state of biodiversity for a given area of land. Ecosystem services are adversely affected by an increase in manufacturing activities. For instance, the use of machinery and the underlying energy mix on which manufacturers rely (such as the burning of fossil fuels or coal for electricity) has an impact on biodiversity. Uncontrolled increases in manufacturing activities will demand more energy and generate higher levels of pollution, negatively affecting nature's ability to provide ecosystem services. GID Biodiversity value ecosystem services using the predecessor of the Ecosystem Services Valuation Database (ESVD), namely the TEEB database. The ESVD was developed by The Economics of Ecosystems and Biodiversity (TEEB), where the TEEB Database providing median values per biome (see explanation box 2 for further details on monetisation).

During the analysis, we combine the estimated number of US$ output generated by the subsectors of the manufacturing sector in Singapore mapped from GTAP 2016 in 2024 (Figure 1) to estimate the biodiversity impact of the sector in Singapore. Figure 2 shows a visual representation of the calculation performed in the analysis, and Explanation Box 3 in Appendix details the steps taken to calculate a selected subsector's biodiversity impact.

Figure 1: Manufacturing subsectors share of Singapore's total manufacturing output mapped to the subsectors from GTAP 2016

Manufacturing Subsectors	% contribution
Computer, electronic and optical products	27.78%
Chemical products	20.10%
Petroleum products, coal products	19.10%
Machinery and equipment	7.39%
Transport equipment	3.76%
Basic pharmaceutical products	3.76%
Metal products	3.24%
Electrical equipment	2.73%
Rubber and plastic products	2.70%
Manufactures Not Elsewhere Classified	2.45%
Paper products, publishing	2.40%
Mineral products	1.17%
Metals	1.00%
Motor vehicles and parts	0.82%
Ferrous metals	0.56%
Leather products	0.47%
Wearing apparel	0.21%
Textiles	0.19%
Wood products	0.18%

Figure 2: Visual representation of the calculation performed in the analysis



Explanation Box 1: PDF.ha.yr

What is a PDF.ha.yr?
PDF.ha.yr is a footprint measure to quantify the biodiversity impact on the state of an ecosystem. PDF stands for Potentially Disappeared Fraction, the proportion of species expected to be lost in an area due to human pressures (such as land use, emissions, water use, or pollution).

How to interpret a PDF.ha.yr?
It indicates the fraction of species lost (or at risk of loss) in one hectare of land over the course of one year due to human pressures.1 PDF.ha.yr can be interpreted as a 100% loss of one species across one hectare for one year, or a 10% loss across ten hectares, or equivalent combinations.

Explanation Box 2: Monetisation Through Ecosystem Services

What is Monetisation?
Impact monetisation (or impact valuation) is the process of expressing environmental and social impacts into financial terms. For biodiversity, it means expressing ecological changes such as habitat loss or pollution in dollar values that reflect the cost of damage, restoration, or lost benefits. This allows impacts to be compared with financial performance and made visible in business decisions.

What are Ecosystem Services?
Ecosystem services are the benefits people gain from nature, supported by biodiversity. They are classified in four kinds:
- Provisioning services (food, water, materials),
- Regulating services (carbon storage, water purification),
- Supporting services (soil formation, nutrient cycling),
- Cultural services (recreation, heritage).

Businesses depend on these services for inputs, stability, and resilience—making their loss a direct financial risk.

This approach values biodiversity loss by estimating the economic cost of reduced ecosystem services. For example, deforestation may be valued through the cost of (man-made) water purification facilities or restoration per hectare. Databases such as the Ecosystem Services Valuation Database (ESVD) provide benchmarks that allow biodiversity loss to be expressed in dollars and compared to returns.

How to Interpret Results
Biodiversity impact expressed in monetary terms represents the US$ of forgone benefits that ecosystem services could have provided if the activity generating the impact didn't take place – and the surrounding nature would be allowed to grow back to its pristine state.

Why Use Monetisation?
Monetisation puts biodiversity in the language of finance, enabling comparison with other impacts, prioritisation of hotspots, and clearer engagement with stakeholders. It supports compliance with frameworks like TNFD and the Global Biodiversity Framework (Target 15), which require disclosure and management of biodiversity risks. Above all, it bridges science and finance, helping practitioners integrate biodiversity into strategy and capital allocation.

Impact Assessment

Figure 3: Biodiversity impact of Singapore's manufacturing and related value chain sector by impact driver

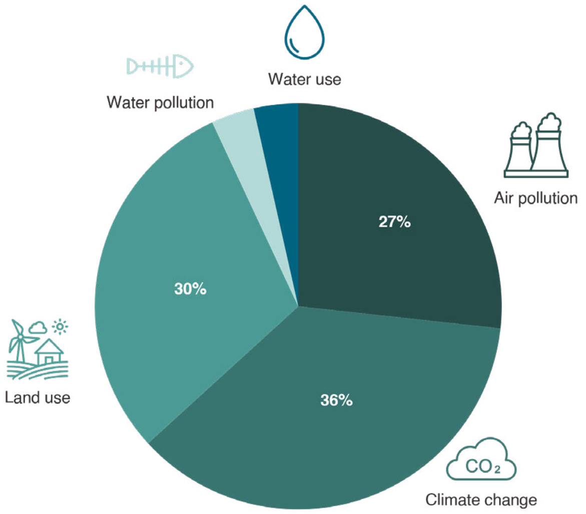


Figure 4: Biodiversity impact of the Singapore manufacturing sector - Value Chain split

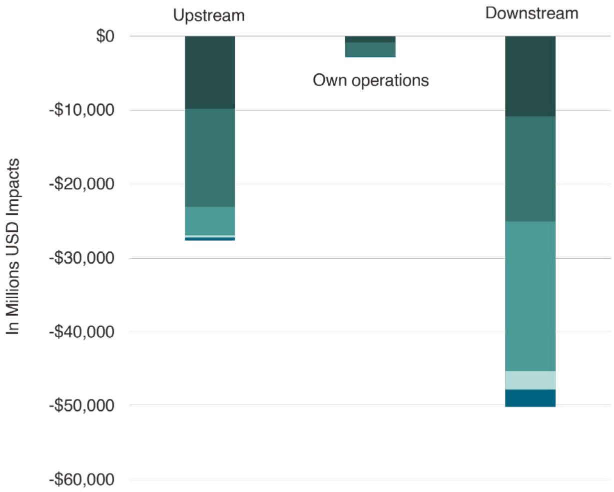


Figure 3 shows the direct and indirect biodiversity impacts of Singapore's total manufacturing output in 2024. When measured in PDF.ha.yr, the total biodiversity loss attributed to the manufacturing sector amounts to approximately 22,355,900 PDF.ha.yr. This figure reflects both direct and indirect (upstream and downstream) impacts of the various industries operating within Singapore's manufacturing sector. In monetary terms, the estimated biodiversity loss amounts to approximately US$80.7 billion in 2024. Overall, this suggests that for every US$1 of output produced by the manufacturing sector and its associated value chain, US$0.26 of biodiversity loss is generated.

Among the five biodiversity drivers assessed (climate change, air pollution, water pollution, land use, and water use), climate change, land use, and air pollution are by far the most significant, accounting for more than 90% of total biodiversity impact. This can be attributed to manufacturing activities that accelerate issues such as climate change and air pollution. For example, increased manufacturing production requires additional resources, such as raw materials and electricity to power machinery, all of which will result in an increase in greenhouse gas emissions and air pollution if few mitigation measures are put in place. With approximately 95% of Singapore's energy generation relying on natural gas imports (Energy Market Authority – a, n.d.), it is unsurprising that climate change and air pollution account for almost two-thirds of the manufacturing sector's total biodiversity impact, given the substantial energy requirements of industrial operations. A potential reason for the high impact on climate change and air pollution can be attributed to the unique composition of Singapore's electricity sector. Given the substantial electricity demand from the manufacturing sector, the composition of Singapore's electricity supply has a significant influence on the amount of greenhouse gases generated, thereby affecting the level of air pollution and the extent of climate change the nation experiences.

With a relatively small geographical land area, Singapore is unable to rely on domestic renewable energy sources at scale and therefore depends heavily on a single fuel – liquefied natural gas (LNG) – for power generation. Although LNG is often regarded as a cleaner energy source compared to coal and other fossil fuels, it still has a greater environmental impact than renewable sources such as solar or wind power. The combustion of natural gas releases large volumes of greenhouse gases such as carbon dioxide and methane, contributing to climate- and biodiversity-related impacts such as temperature rise and ocean acidification, which directly and indirectly threaten species survival and ecological balance.

Across the value chain, indirect activities account for more than 95% of total biodiversity impact, with only 4% originating from companies' own operations. Downstream activities account for approximately 62% of total biodiversity impact, suggesting that most biodiversity loss is attributable to clients of manufacturers and activities that use manufactured goods as inputs for their own operations. This is particularly evident in certain manufacturing subsectors in within Singapore. For instance, the petrochemical industry produces large volumes of refined fuels and chemical products for domestic use and export. While the manufacturing process itself is relatively regulated and spatially concentrated, the downstream use of these products – especially their combustion in transport, power generation, and industrial activities – generates substantial greenhouse gas emissions and air pollutants. These emissions contribute to climate change and environmental degradation, which in turn exert widespread pressure on ecosystems and biodiversity both within Singapore and in regions where the products are ultimately consumed. See Figure 5 below for breakdown.

Figure 5: Breakdown of biodiversity impact drivers across value chain

Impact Driver (monetised)/ Value Chain Direction	Air pollution	Climate change	Land occupation	Water pollution	Water use	Total
up	12.19%	16.46%	4.74%	0.37%	0.47%	34.24%
self	1.08%	2.39%	0.00%	0.00%	0.09%	3.57%
down	13.46%	17.63%	25.09%	3.05%	2.96%	62.20%
Total	26.74%	36.48%	29.83%	3.42%	3.53%	100.00%

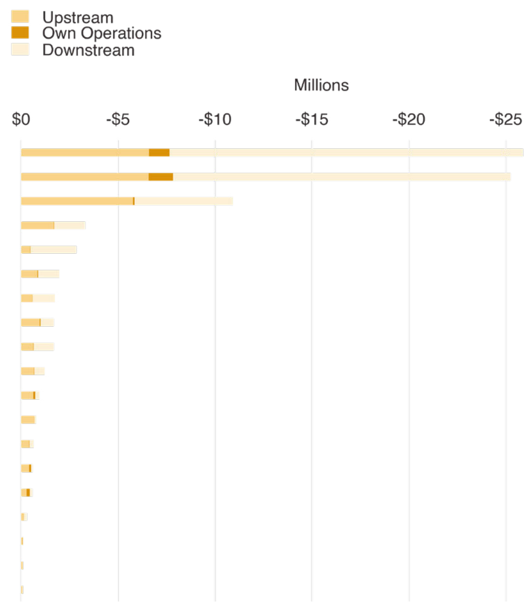
Further analysis shows that the top five manufacturing subsectors, which together account for 78% of Singapore's manufacturing output, are responsible for 85% of the sector's biodiversity impact. However, output share is not always proportional to biodiversity impact. For example, the petroleum and coal products subsector contributed about 19% of manufacturing output but generated more than 32% of total biodiversity impact. Most of this impact occurs downstream (70%) when these products are combusted for energy. The combustion of fossil fuels releases large quantities of carbon dioxide and methane, the primary greenhouse gases driving climate change. Rising temperatures disrupt habitats for native species, thereby accelerating biodiversity loss.

Similarly, the chemical products subsector accounted for more than 31% of total biodiversity impact, despite representing only about 20% of manufacturing output. Approximately 69% of the subsector's negative impact arises from downstream activities, where chemical products are used as inputs for other sectors such as agriculture.

In contrast, the computer, electronics, and optical products subsector, the largest contributor to manufacturing output (27.8%), ranked only third in terms of biodiversity impact (13%). This suggests that the nature of operations within subsectors plays a significant role in determining biodiversity outcomes.

Figure 6: Key impact drivers and intensity across sub-sectors

Subsector	Output %	Output in bln $	Impact %
Petroleum, coal products	19.1%	60.4	32.07%
Chemical products	20.1%	63.5	31.28%
Computer, electronic and optical products	27.8%	87.8	13.55%
Machinery and equipment	7.4%	23.4	4.10%
Basic pharmaceutical products	3.8%	11.9	3.53%
Paper products, publishing	2.4%	7.6	2.45%
Transport equipment	3.8%	11.9	2.15%
Metal products	3.2%	10.3	2.08%
Rubber and plastic products	2.7%	8.5	2.08%
Electrical equipment	2.7%	8.6	1.50%
Manufactures	2.5%	7.7	1.17%
Leather products	0.5%	1.5	0.96%
Metals	1%	3.2	0.80%
Mineral products	1.2%	3.7	0.73%
Ferrous metals	0.6%	1.8	0.73%
Motor vehicles and parts	0.8%	2.6	0.37%
Textiles	0.2%	0.6	0.16%
Wood products	0.2%	0.6	0.14%
Wearing apparel	0.2%	0.6	0.13%



Implications for the Singapore Manufacturing Sector

Imperative for a greater green energy mix in Singapore's electricity grid:

With almost 95% of Singapore's electricity generated from natural gas imports, it is unsurprising that climate change and air pollution account for almost two-thirds of the manufacturing sector's biodiversity impact, given that industry accounted for 39.4% of total electricity consumption in Singapore in 2024 (Energy Market Authority – b, n.d.).

In 2024, Singapore's Gross Domestic Product (GDP) rose by 4.4% to reach approximately US$562.64 billion, with the manufacturing sector growing by 4.3% over the full year (MTI, 2025). Taking into account the US$80.7 billion negative biodiversity impact generated by the manufacturing sector, this amounts to around 14.34% of overall GDP in 2024 and far exceeds both the overall GDP growth rate and that of the manufacturing sector for the year. As such, this presents a compelling case for reducing the biodiversity impact of the manufacturing sector while balancing the need for continued growth. Given the unique challenges and limitations of Singapore's electricity sector – which is a key component of manufacturing operations – transitioning to cleaner energy sources appears to be one of the most practical pathways for Singapore.

Regulatory and policy implications and interventions:
The findings in this whitepaper can also help strengthen existing government incentives and funding schemes designed to support businesses in transitioning to a low-carbon and sustainable future. For example:

- The Energy Efficiency Grant (EEG), which provides co-funding to help businesses invest in energy-efficient equipment (Enterprise Singapore – a, n.d.), could be expanded to cover a wider range of manufacturing subsectors.
- The Enterprise Financing Scheme – Green, which supports companies in developing solutions to reduce waste, resource use, or greenhouse gas emissions (Enterprise Singapore – b, n.d.), could be extended beyond the 31 March 2026 deadline.
- The Resource Efficiency Grant for Emissions (REG(E)), which supports manufacturing facilities and data centres in undertaking energy-efficiency and emissions-reduction projects (Economic Development Board – b, n.d.), could be extended beyond its current expiry date of 31 March 2026.

Post-covid trends and green manufacturing:
Following the global COVID-19 pandemic, many countries are seeking to reshore and rebuild manufacturing capabilities closer to home. A clearer understanding of the sources and drivers of negative impacts across manufacturing subsectors, combined with greater control over more regionalised value chains, can help enhance the resilience and sustainability of the sector.

Conclusion

In summary, this white paper demonstrates that within Singapore's manufacturing sector, the bulk of its biodiversity footprint is concentrated in climate-driven impacts, with total losses of approximately 22,355,900 PDF.ha.yr valued at around US$80.7 billion in 2024. Climate change accounts for approximately 36% of this impact, followed by air pollution at around 27%. These impacts arise from both direct and indirect operations, with upstream (34%) and downstream (62%) activities accounting for the majority of biodiversity loss.

While these findings provide a robust, economy-wide perspective, they should be interpreted in light of the methodological limitations. In particular, the use of aggregated country- and sector-level data means that the results reflect average impacts rather than firm-specific or activity-level performance. As a result, more sustainable manufacturers may exhibit similar impact profiles to less sustainable peers operating within the same sector. In addition, the reliance on environmental and biodiversity datasets that may not be updated frequently introduces uncertainty, as recent changes in land use, industrial practices, or regulatory frameworks may not be fully captured. Despite these limitations, the analysis remains valuable for identifying broad patterns, priority impact drivers, and systemic risks within the manufacturing sector.

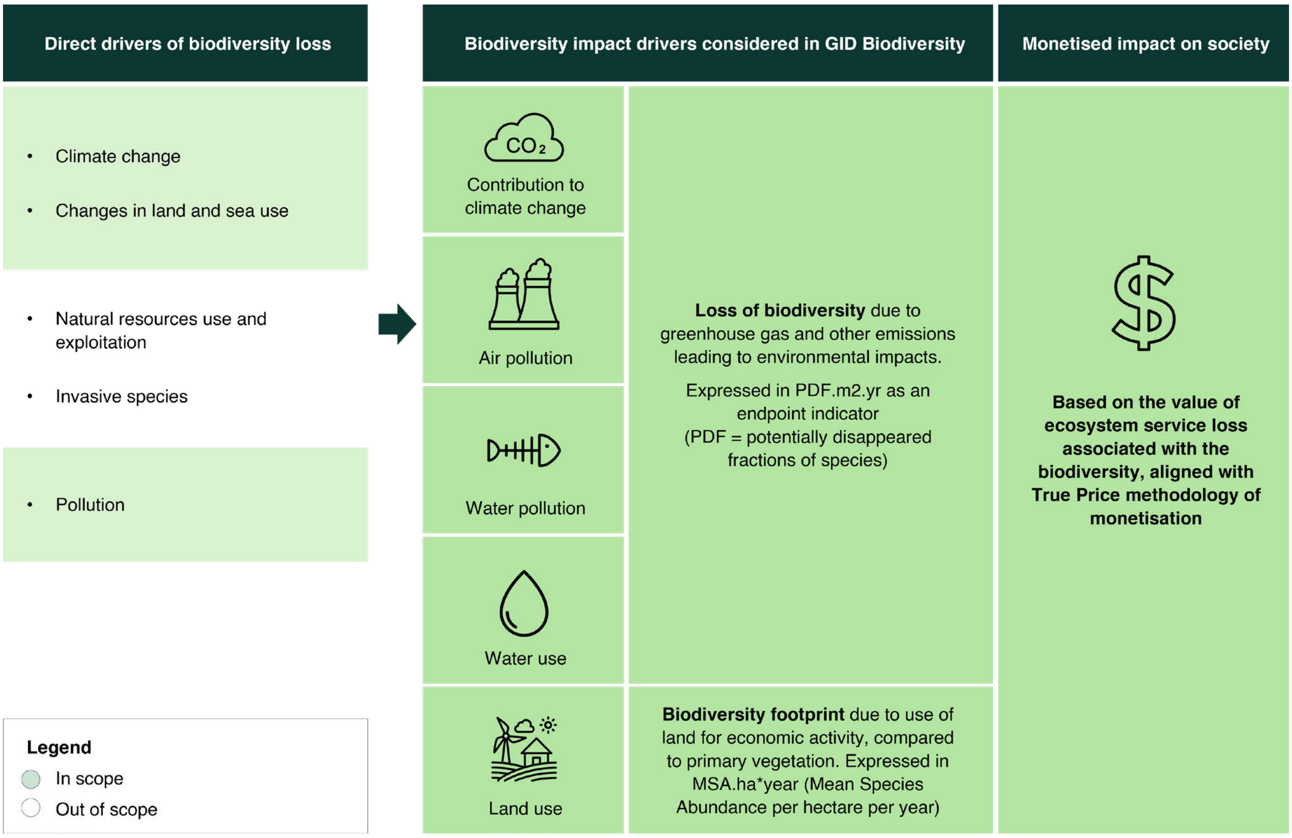
Translating biodiversity impacts into financial terms provides policymakers with an additional tool to assess environmental externalities and trade-offs when determining the optimal subsector composition of Singapore's economy. Even allowing for data and modelling constraints, the scale of the estimated impacts highlights the urgency of mitigation efforts. The findings point to several priority actions, including greening Singapore's electricity grid and expanding or enhancing schemes such as the Energy Efficiency Grant (EEG) and the Enterprise Financing Scheme – Green, to encourage wider adoption of energy-efficient and low-impact practices across manufacturing subsectors. Addressing these challenges will be critical to balancing continued industrial growth with the protection of biodiversity and long-term environmental resilience.

Appendix

Methodology: The Global Impact Database

The Global Impact Database (GID) provides a comprehensive framework for assessing biodiversity impacts across value chains, leveraging both quantitative and monetized approaches. The methodology integrates data from global databases, such as GTAP, FAOSTAT, and GIS sources like GLOBIO and WWF, to evaluate the interconnectedness of industries and their environmental performance across 140 countries and 65 sectors. Biodiversity loss is quantified using indicators such as Mean Species Abundance (MSA) and Potentially Disappeared Fractions (PDF), which measure the reduction in species abundance or probability of occurrence compared to undisturbed habitats. These indicators are then converted to a common unit in PDF. The drivers of biodiversity loss included in the database are land use, climate change, air pollution, and water pollution and water use.

The GID methodology employs a full chain impact (FCI) approach to attribute biodiversity impacts across the entire value chain, ensuring a holistic assessment. It uses Multi-Regional Input-Output (MRIO) analysis to link economic activities to environmental impacts, translating emissions and land use into relative species loss across terrestrial, freshwater, and marine ecosystems. The methodology also incorporates monetization by valuing ecosystem services (ESS) such as carbon storage, air purification, and water regulation. This allows biodiversity impacts to be expressed in monetary terms, providing a tangible measure of the economic magnitude of biodiversity loss.



Explanation Box 3: Calculation Example

In this box, we display an example of the calculation that we have performed to generate the results of the analysis. We use the climate change impact for direct operations as an example.

1. Footprint Impact
First step is to take a measure of added value of the Singapore electricity sector and multiply it with the GID country sector value for the electricity sector of Singapore.

$$(\text{US\$})\ \text{Total Manufacturing Output}_{\text{Singapore, Chemical Products}} \times$$
$$(\text{PDF.ha.yr/US\$})\ \text{GID Biodiversity}_{\text{Climate Change, Singapore, Chemical Products}}$$
$$= 63{,}528{,}728{,}809 \times 0.000028482671 = \mathbf{1{,}809{,}467\ PDF.ha.yr}$$

2. Monetise Impact
Second step is to monetise the footprint that we have calculated.

$$\text{PDF.ha.yr} \times (\text{US\$/PDF.ha.yr})\ \text{Monetisation factor}_{\text{Climate Change}}$$
$$= 1{,}809{,}467 \times -4273 = \mathbf{-\ 7{,}731{,}840{,}527\ US\$}$$

This calculation is performed across the board for all impacts and value chain parts (upstream value chain and direct operations).

References

ASEAN Centre for Biodiversity. (2023). ASEAN Biodiversity Outlook 3. ABO3. https://abo3.aseanbiodiversity.org/

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., & van den Belt, M. (1998). The value of the world's ecosystem services and natural capital. Ecological Economics, 25(1), 3–15. https://doi.org/10.1016/S0921-8009(98)00020-2

Economic Development Board. (n.d.-a). Asia's economic powerhouse. https://www.edb.gov.sg/en/why-singapore/an-economic-powerhouse.html

Economic Development Board. (n.d.-b). Resource Efficiency Grant for Emissions (REG(E)). https://invest.edb.gov.sg/gov-support/resource-efficiency-grant-for-emissions-reg-e

Energy Market Authority. (n.d.-a). Chapter 2: Energy Transformation. https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter2

Energy Market Authority. (n.d.-b). Chapter 3: Energy Consumption. https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter3

Enterprise Singapore. (n.d.-a). Energy efficiency grant. https://www.enterprisesg.gov.sg/financial-support/energy-efficiency-grant

Enterprise Singapore. (n.d.-b). Enterprise Financing Scheme – Green. https://www.enterprisesg.gov.sg/financial-support/enterprise-financing-scheme---green

Impact Institute (2025) Global Impact Database (GID) Biodiversity (version 1.7.0). https://www.impactinstitute.com/gid-biodiversity-impact-data/

MTI. (2025, February). MTI Maintains 2025 GDP Growth at "1.0 to 3.0 Per Cent." https://isomer-user-content.by.gov.sg/166/736a0505-140c-4478-9978-2943a6b6353c/FullReport_AES2024.pdf

SingStat. (2024). Greenhouse Gas Emissions By Sector. https://tablebuilder.singstat.gov.sg/table/TS/M891491

Sodhi, N. S., Posa, M. R. C., Lee, T. M., Bickford, D., Koh, L. P., & Brook, B. W. (2010). The state and conservation of Southeast Asian biodiversity. Biodiversity and conservation, 19(2), 317-328.

Stibig, H. J., Achard, F., Carboni, S., Raši, R., & Miettinen, J. (2014). Change in tropical forest cover of Southeast Asia from 1990 to 2010. Biogeosciences, 11(2), 247-258.

Visit Singapore. (n.d.). Advanced Manufacturing. https://www.visitsingapore.com/mice/en/why-singapore/dynamic-industries/advanced-manufacturing/#

Yap, W. Q. (2025, December 5). Singapore commits record $37 billion to drive research, Innovation and Enterprise over next five years. The Straits Times. https://www.straitstimes.com/singapore/singapore-commits-record-37-billion-to-drive-research-innovation-and-enterprise-over-the-next-five