Towards sustainable growth in ASEAN

Circular economy research report 2024

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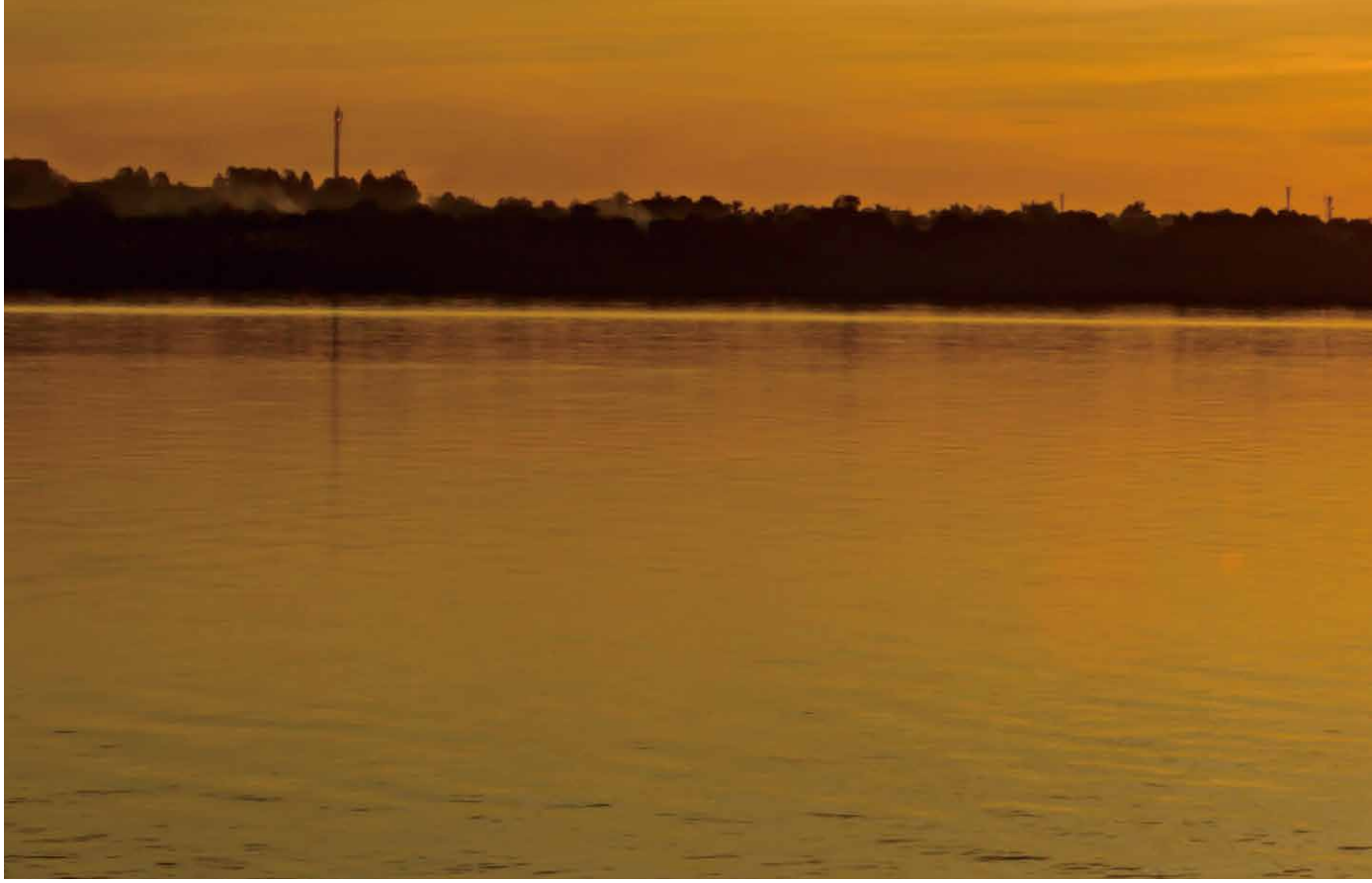

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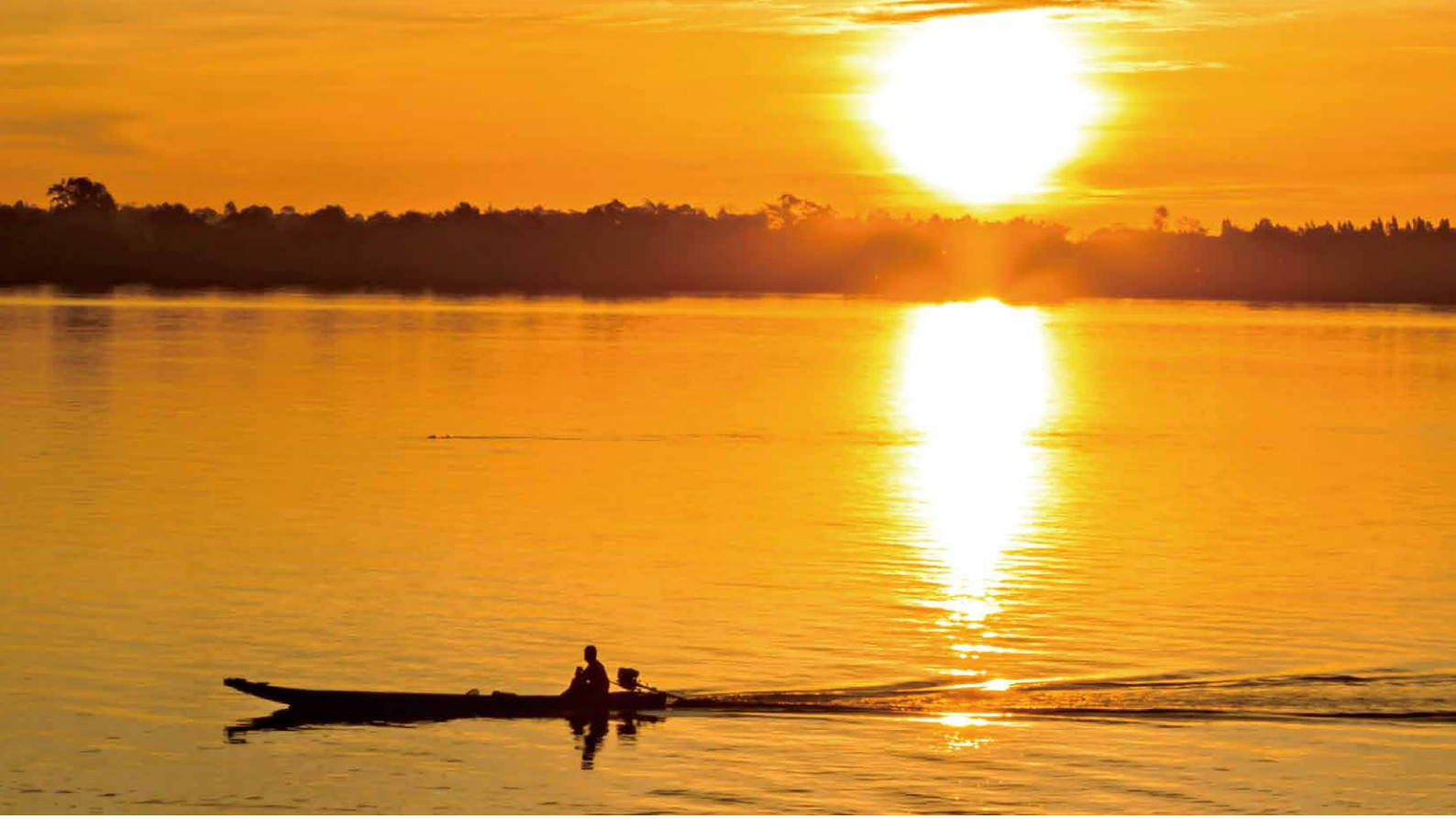


Introduction

Climate change and other global environmental issues are growing more serious every year. The international community is calling on businesses to take strong action to address these threats and make their business transition to be more sustainable. Furthermore, various regulations and voluntary rules are being established in response to these issues.

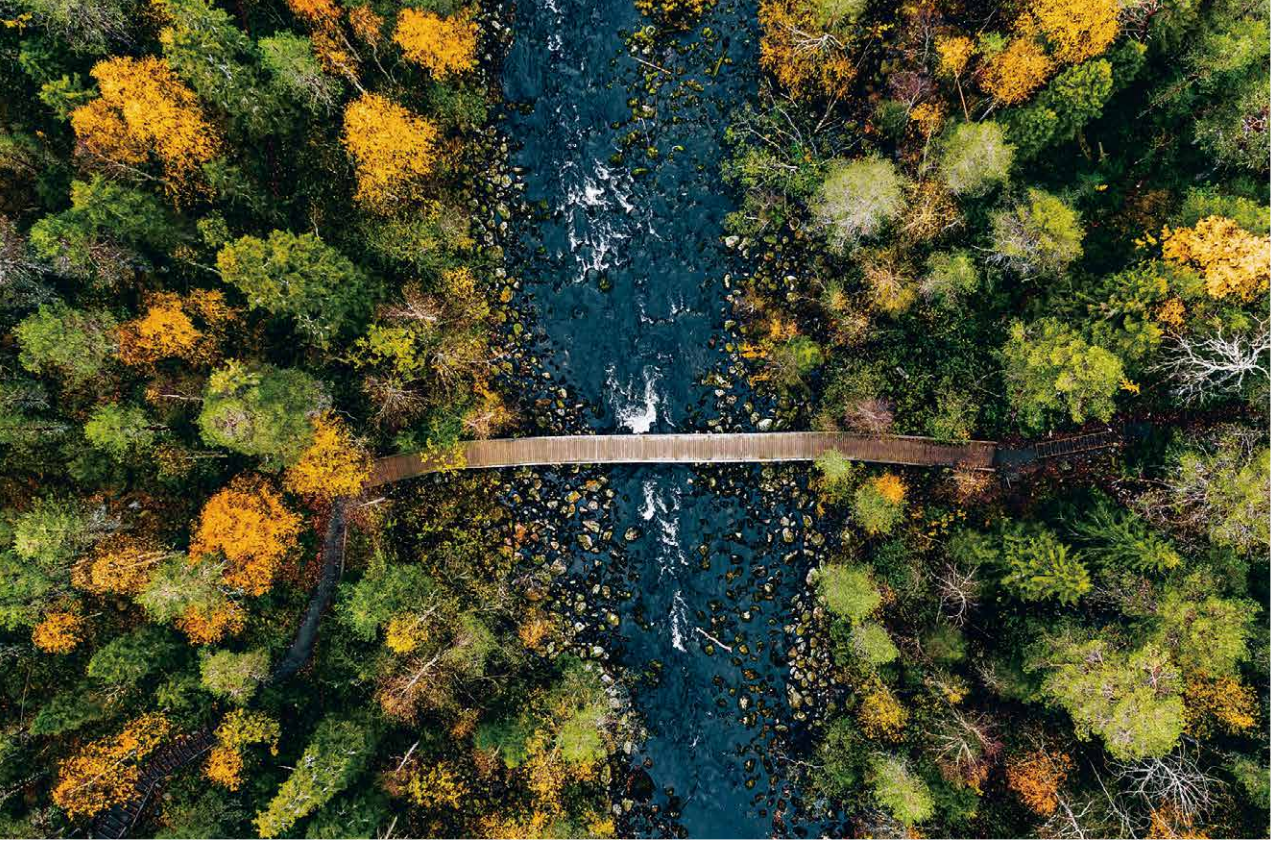
ASEAN (Association of Southeast Asian Nations) member states are among the world's fastest growing economies, yet their economic resilience is increasingly threatened by population growth, resource depletion, unsustainable patterns of raw material consumption and climate change. A new model of regional economic growth is needed—one that is not reliant on mass resource consumption and waste disposal.

With our base in Asia and extensive business track record in the ASEAN region, we believe Japanese companies, in partnership with local businesses, can make a significant impact. That's why in November 2022, we launched the Executive Sustainability Forum. This is one of the few private sector-led forums for business leaders to discuss and share learnings on key sustainability matters in ASEAN.

In one year since its inception, business leaders from Forum member companies have gathered to discuss the future of sustainable business in Asia. During the 2024 World Economic Forum Annual Meeting in Davos, Switzerland, we released a joint statement aimed at achieving sustainable growth in ASEAN. This report explains PwC's circular economy framework, which served as the basis for these discussions, and lays out the challenges facing ASEAN's transition to a circular economy.

We hope the report will be of assistance to those seeking to undertake circular economy initiatives in ASEAN.

Yuki Isogai
PwC Sustainability
Sustainability Centre of Excellence Lead Partner
PwC Japan Group



Part 1 Circular economy framework

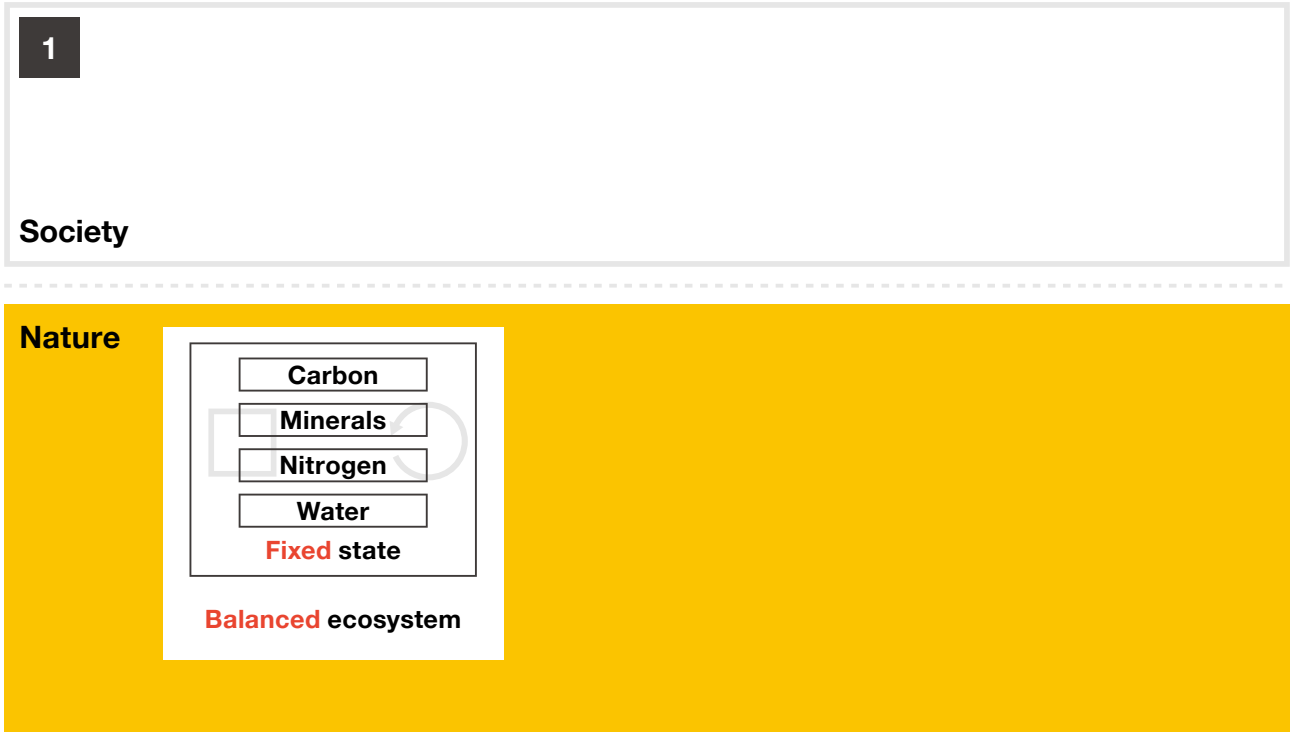
This section of the report provides an overview of PwC's circular economy framework, which served as the basis for discussions by the Executive Sustainability Forum.

The term circular economy has become widely used in recent years but its meaning can vary considerably depending on the context in which it is used. We have therefore developed this framework to provide stakeholders across various industries with a shared understanding of what constitutes a circular economy.

Figure legend for part 1

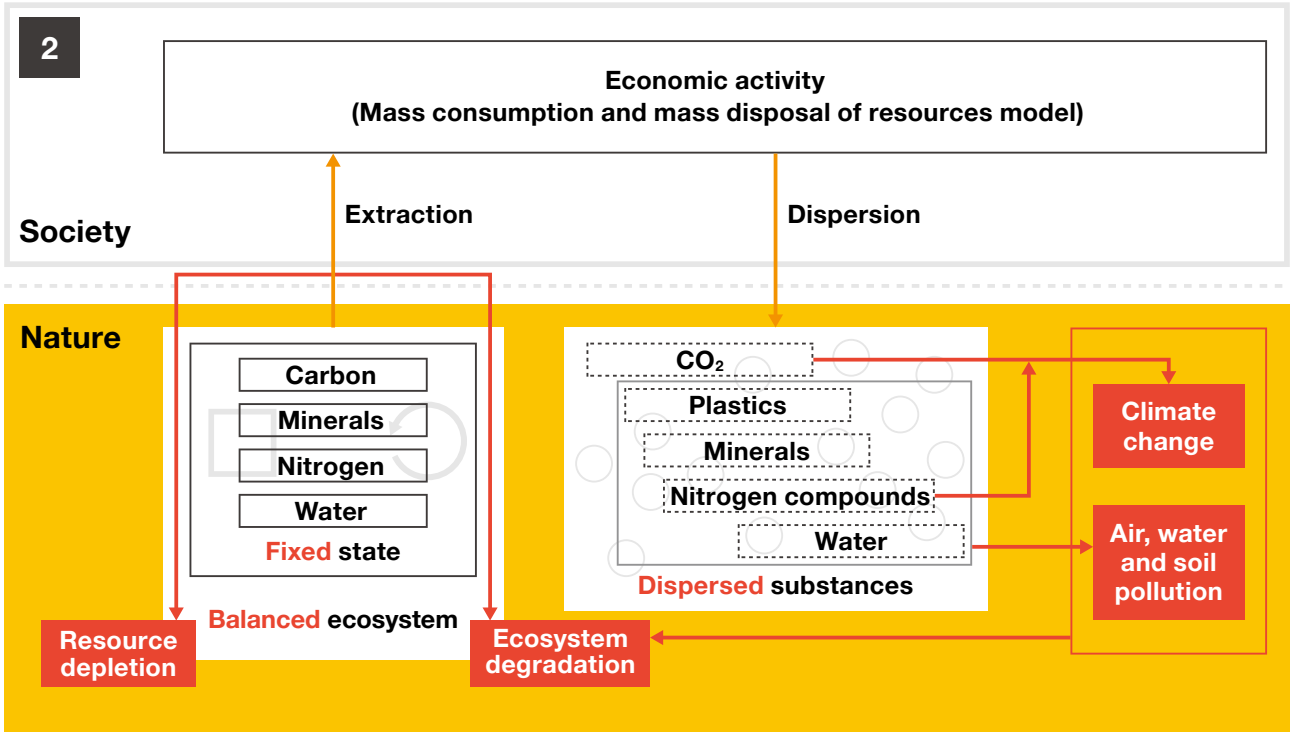
→ : Impact of resource extraction and dispersion on Nature
→ : Natural flow of substances
→ : Flow of substances due to economic activity, negatively impacting nature

Natural substances



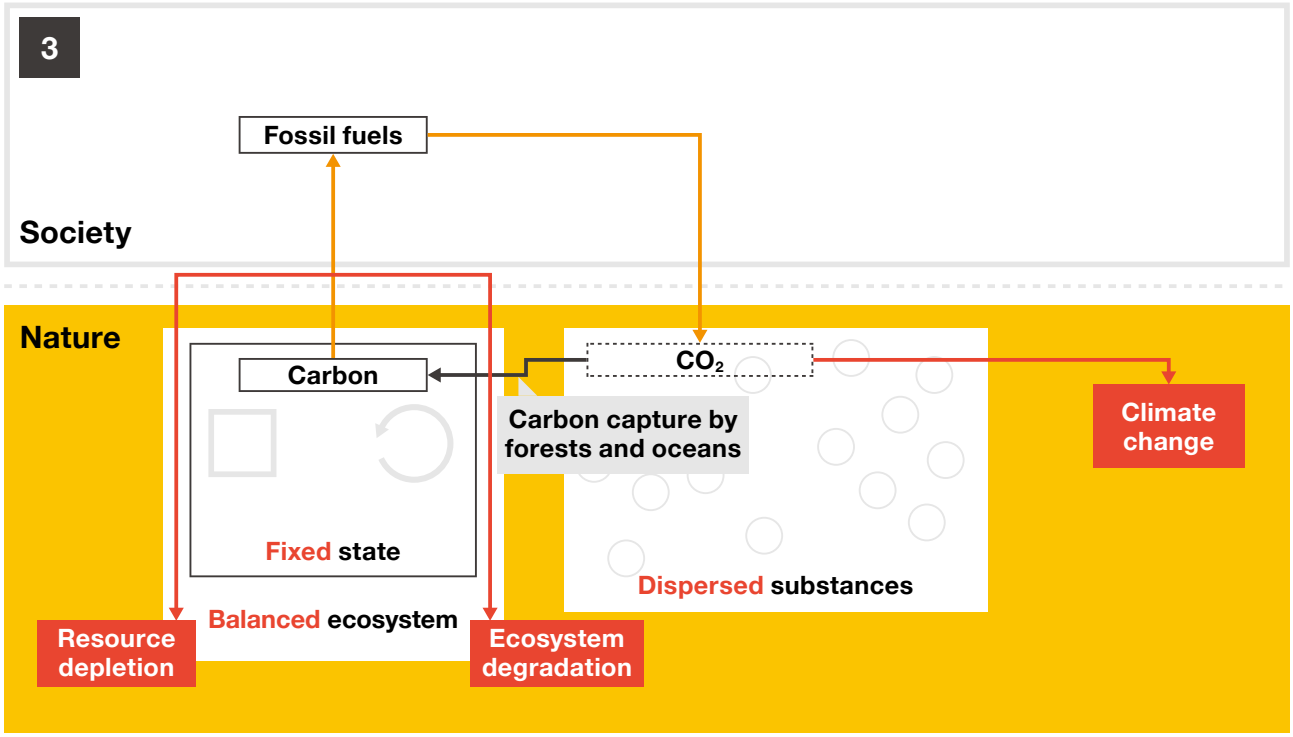
A wide variety of substances exist in the natural world including carbon, minerals, nitrogen and water, which are critical to humans. With the absence of human economic activity, these natural substances would remain in a fixed and balanced state.

Mass extraction and mass dispersion of natural resources through economic activity has a range of negative environmental impacts.



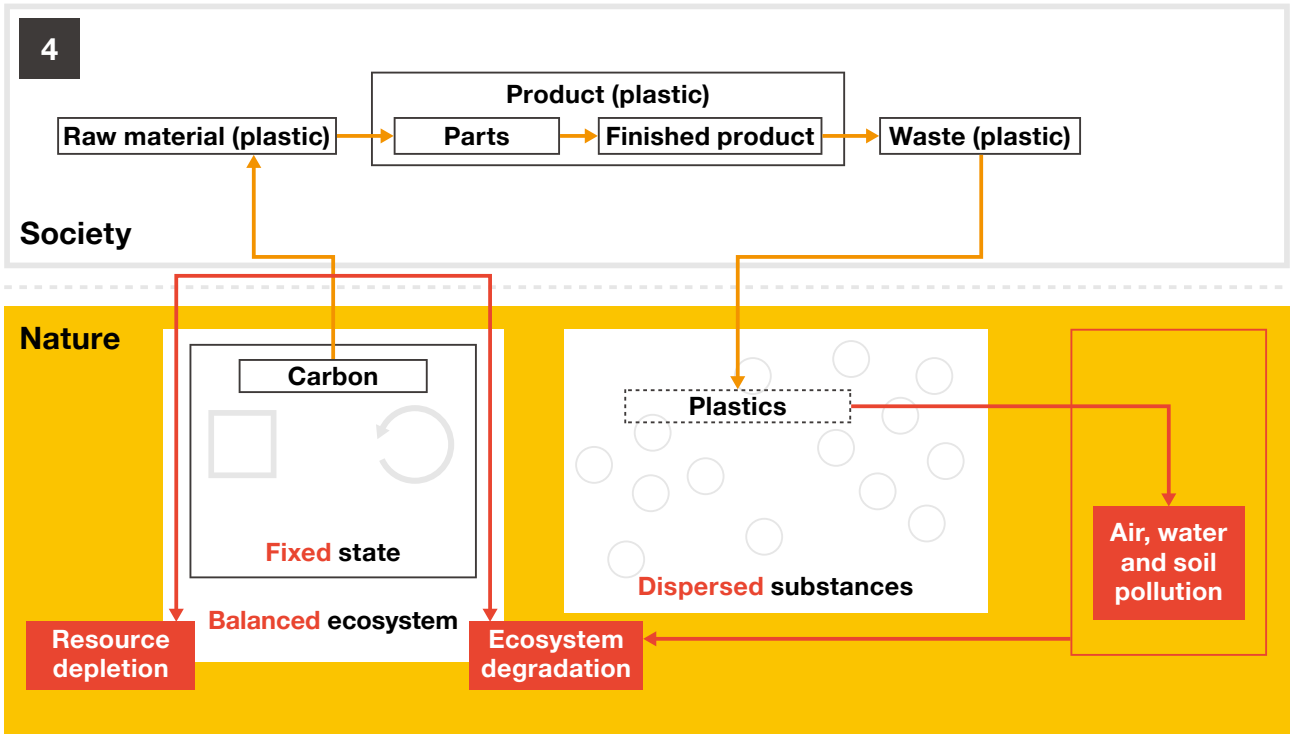
Human economic activity has extracted and disposed of large quantities of these materials, dispersing them in forms that render them unrecoverable. This has resulted in environmental issues such as climate change, pollution, resource depletion and ecosystem degradation.

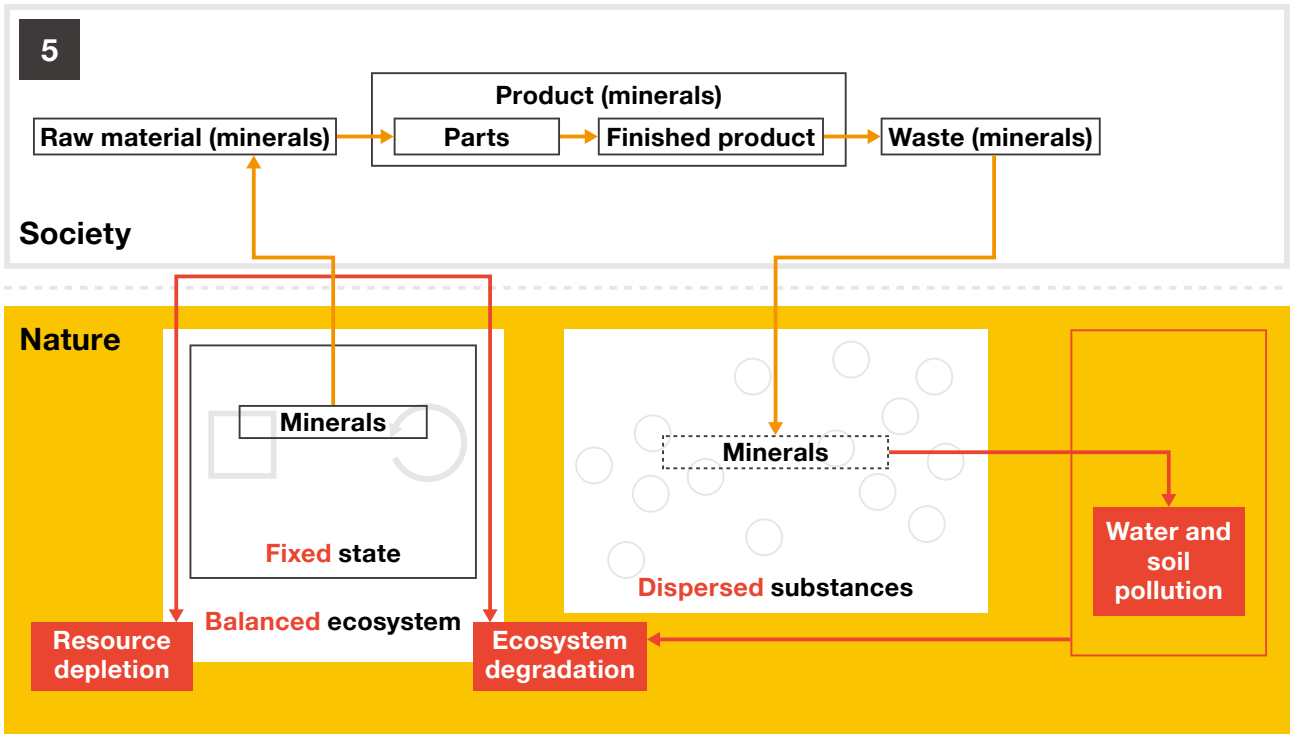
Resource depletion and climate change driven by carbon extraction and dispersion.



Carbon released in the form of CO_2 by burning fossil fuels is the main driver of climate change. In addition, fossil fuels are a finite resource and excessive extraction is raising concerns over resource depletion.

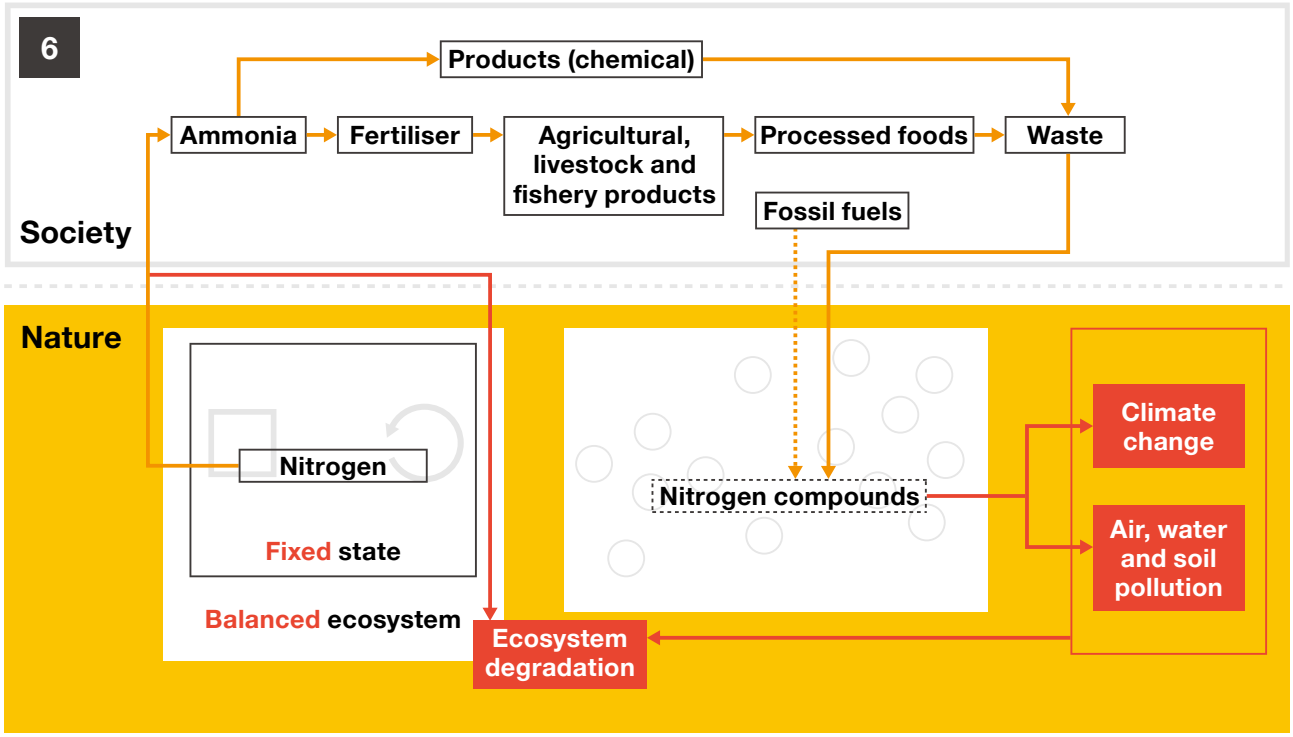
Environmental pollution from plastic and mineral diffusion, and resource depletion from mineral extraction.





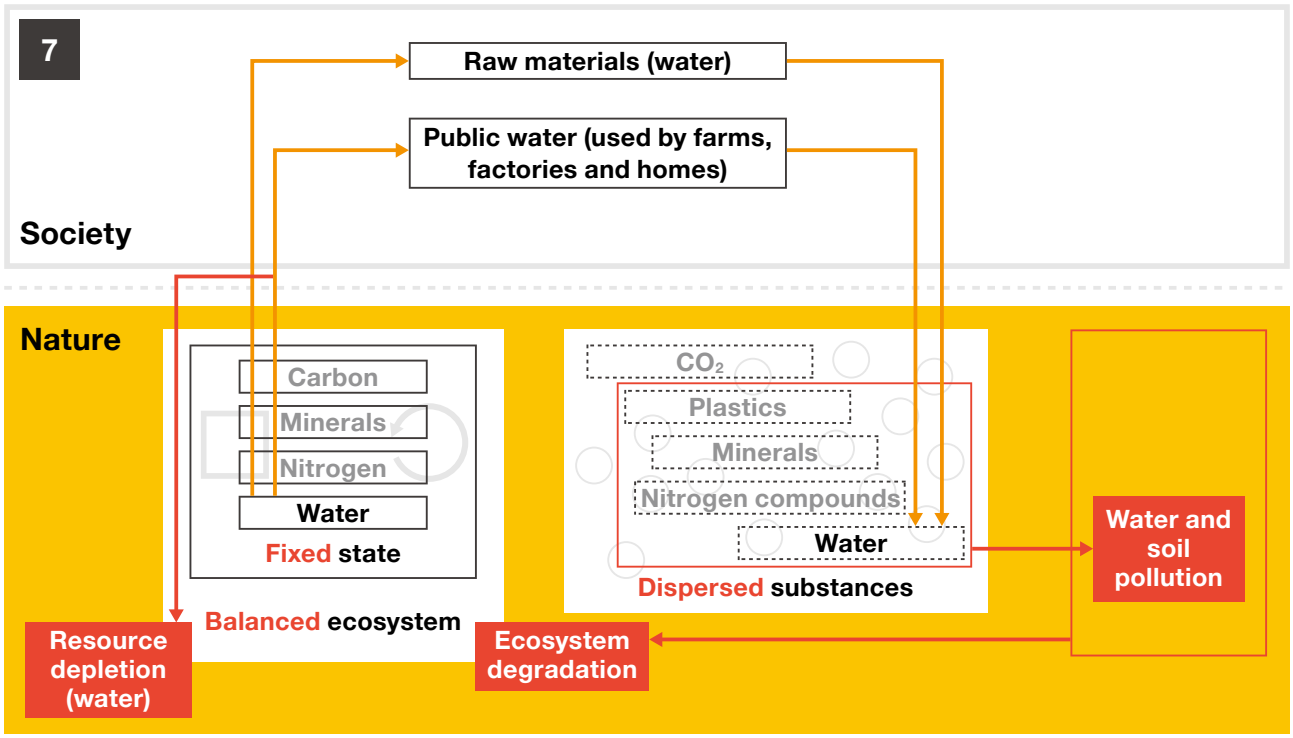
Along with minerals, carbon-derived plastics are used in a wide range of industrial products. Through human economic activity, these are consumed and disposed of in large quantities, polluting the air, water and soil. In the process of dispersion, plastics break down into tiny particles, called microplastics, entering water as well as the air. These have an adverse effect on the health of humans and other living organisms. There is also concern about the depletion of rare minerals due to over-extraction.

Environmental pollution and climate change caused by dispersion of nitrogen.



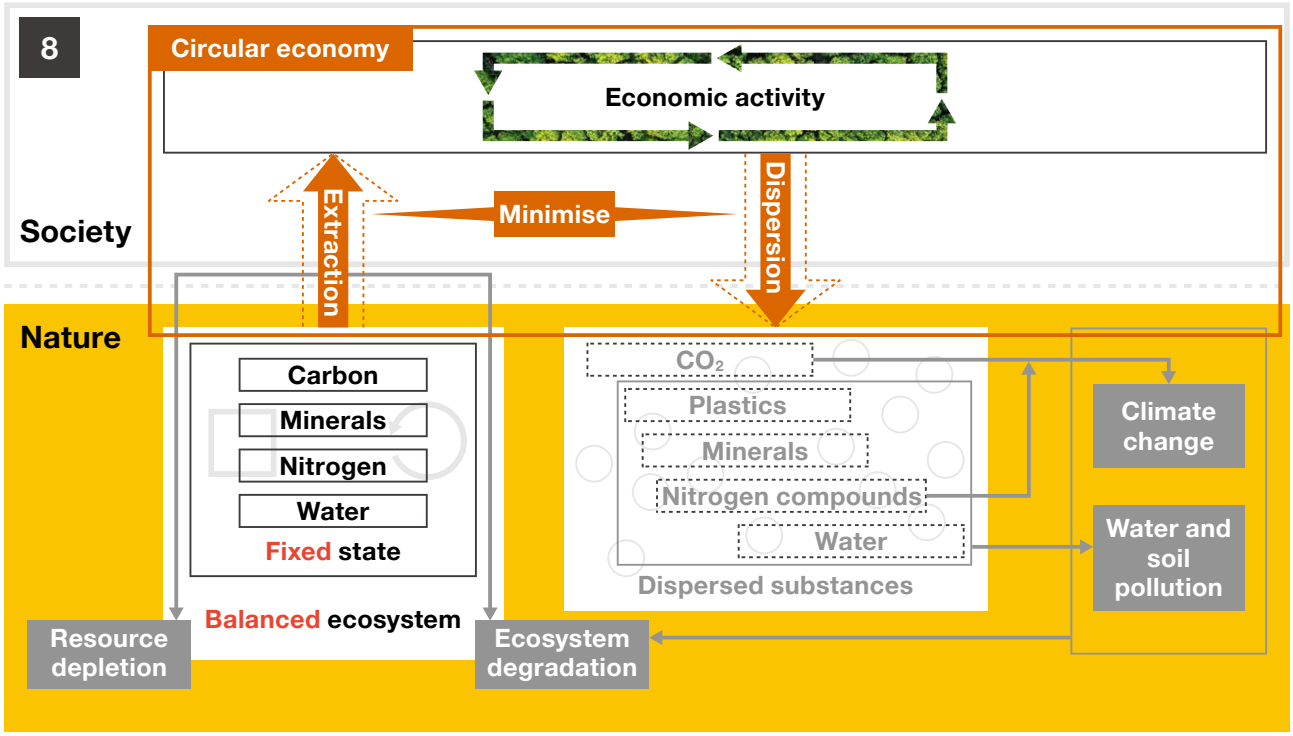
Nitrogen is synthesised in the form of ammonia and used as a raw material in fertilisers and other chemical products. Runoff of nitrogen compounds from farmland and the disposal of chemical waste result in soil and water pollution. Nitrogen is also found in fossil fuels, and nitrogen oxides generated through the combustion of fossil fuels are among the greenhouse gases that contribute to climate change.

Resource depletion and environmental pollution caused by extraction and dispersion of water.



Public water is widely used in the food and beverage industries, as well as by farms, factories and homes. In some areas, water resources are being depleted through over extraction. There is also concern about the degradation of water quality when water is dispersed along with other pollutants.

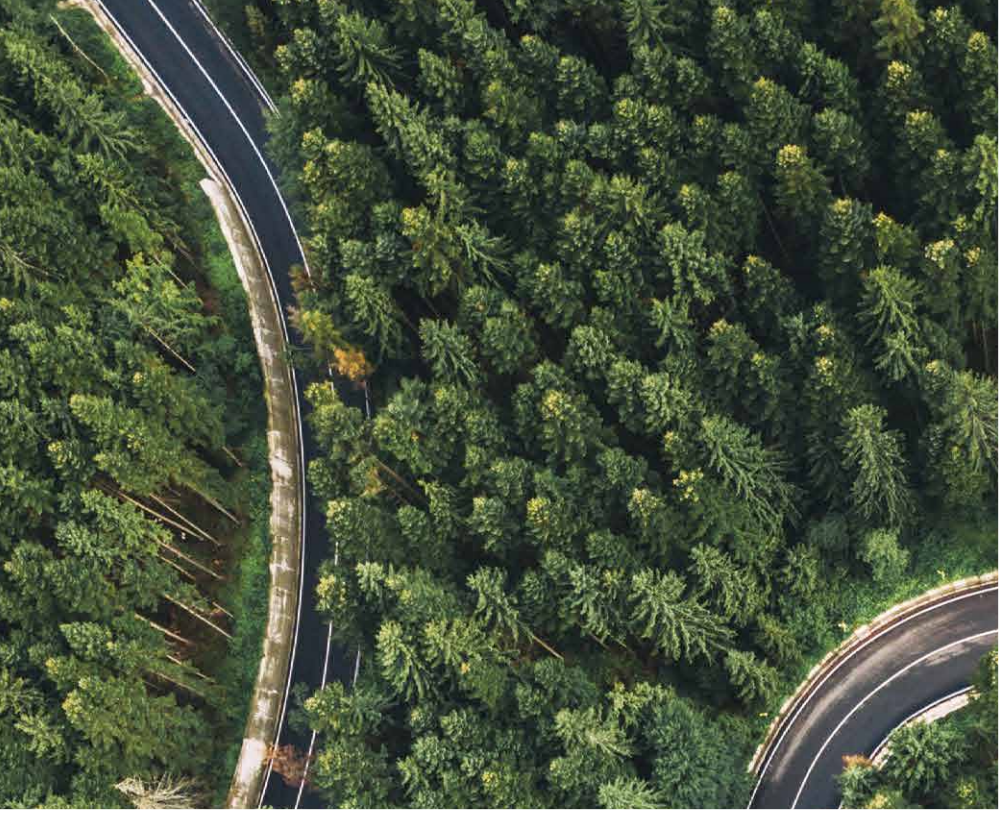
A circular economy balances economic and environmental solutions by circulating materials and minimising resource extraction and dispersion.

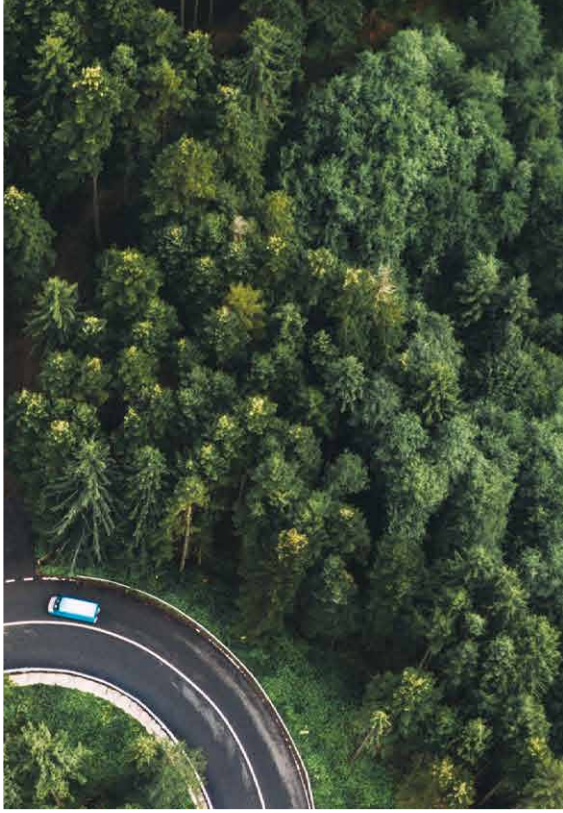


If the current model of economic activity based on the mass extraction and mass dispersal of natural resources continues, it will be difficult to find solutions to the environmental challenges described so far.

What is required is a transition to a circular economy. By minimising resource extraction and diffusion, and increasing recycling materials usage within systems of production and consumption, the circular model aims to solve environmental challenges while simultaneously achieving economic growth.

As indicated above, we have organised the issues to be addressed by resource type, and envision circular transition initiatives as falling into the following three categories: (1) material circularity, (2) bio-circularity and (3) carbon circularity.

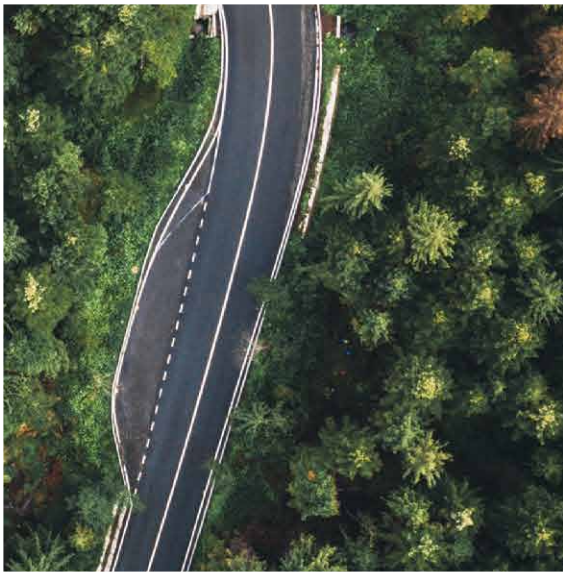


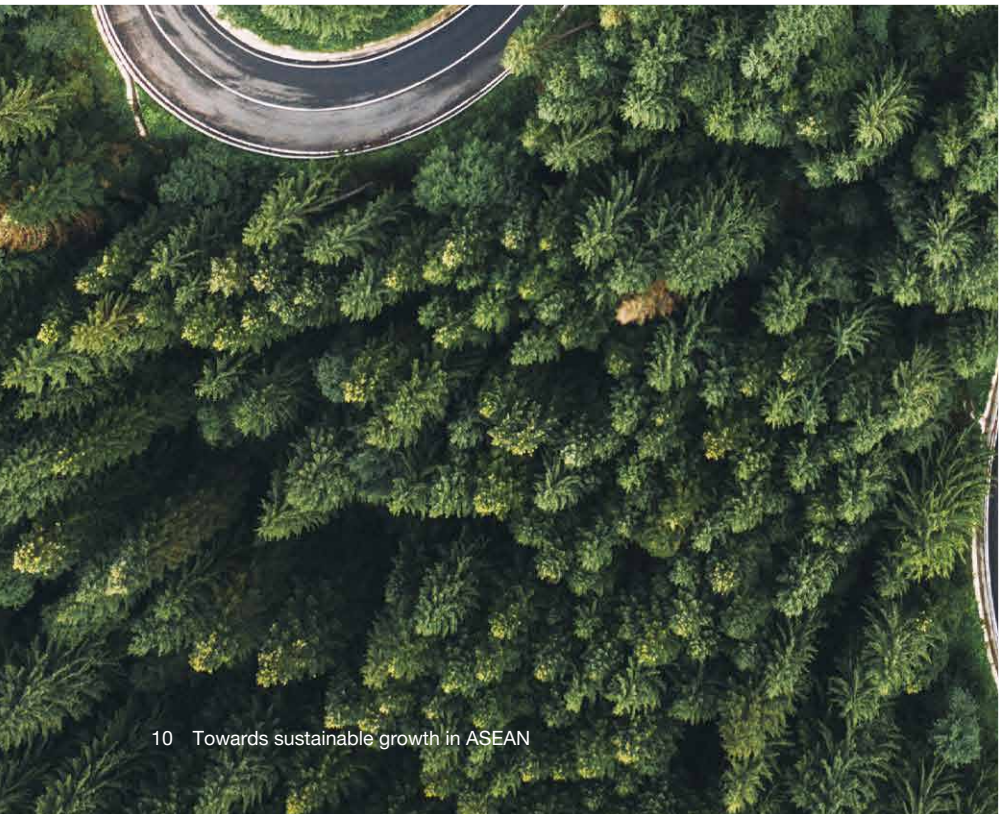


Part 2

Research findings

1. Macro environment for circularity in ASEAN countries
2. Current situation and challenges towards achieving a circular economy in major ASEAN countries
3. Potential business opportunities from promoting a circular economy





1. Macro environment for circularity in ASEAN countries

ASEAN countries must urgently create a circular economy to achieve sustainable growth

This section outlines the macro environment of circularity in ASEAN in four perspectives: (1) continued population and economic growth, (2) increasing resource usage and waste, (3) ASEAN's role as a manufacturing hub and waste disposal site for developed countries and (4) underdeveloped resource reuse and recycling industry.

Continued population and economic growth

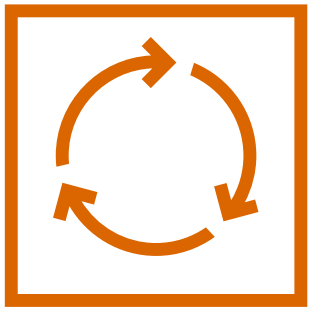
By 2050, population and GDP are expected to increase by CAGR of 0.5% and 3.8% respectively.

Increasing resource use and waste

Resource use per capita is expected to increase by approximately 2.0% annually through 2060.

Role as a manufacturing hub and waste disposal site for developed countries

The major ASEAN countries are waste importers, shouldering the burden of developed countries' waste disposal.



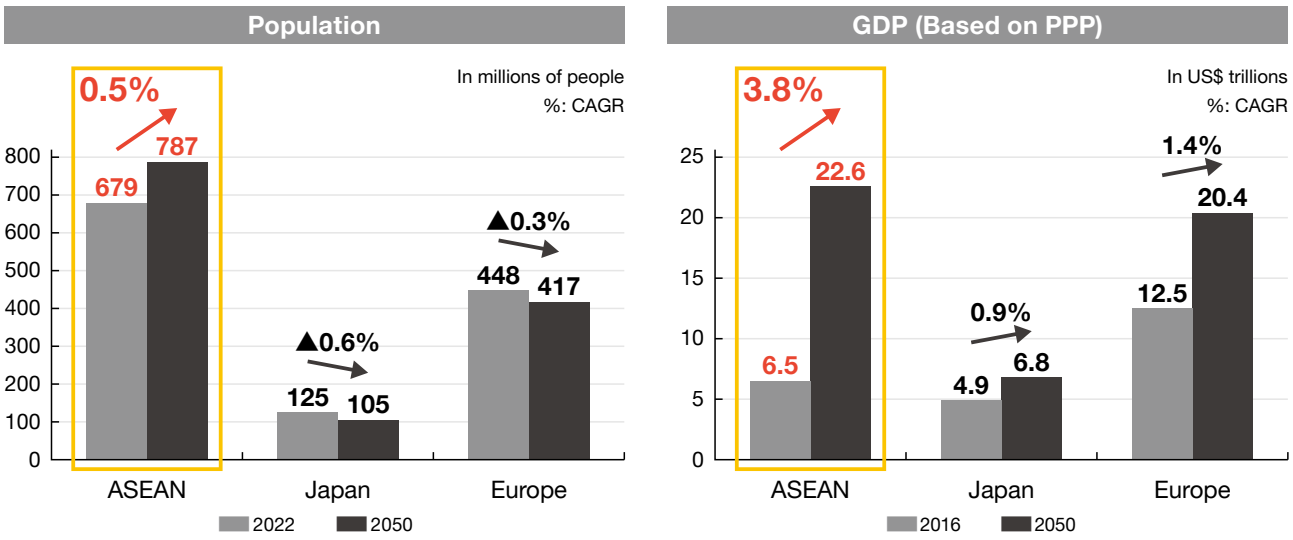
Underdeveloped resource reuse and recycling industry

The total waste recycling rate across ASEAN nations is 2.5% and the circularity rate is only 0.8%.

(1) Continued population and economic growth in ASEAN countries

The total population of ASEAN countries was 679 million in 2022, and forecasts expect this figure to rise at 0.5% per annum and reach 787 million in 2050. The population of Japan will decrease by 0.6% per annum through 2050 and the population of the European Union (EU) will decrease by 0.3% over the same period. While many developed nations and regions are experiencing population decline, projections indicate continued growth in ASEAN countries.

Meanwhile, the ASEAN economy will more than triple its GDP from US$6.5tn in 2016 to US$22.6tn in 2050. This is a growth rate of 3.8% per annum. During this period, forecasts demonstrate annual growth rates of 0.9% and 1.4% for Japan and the EU respectively, indicating that ASEAN economies will maintain relatively high rates of growth.

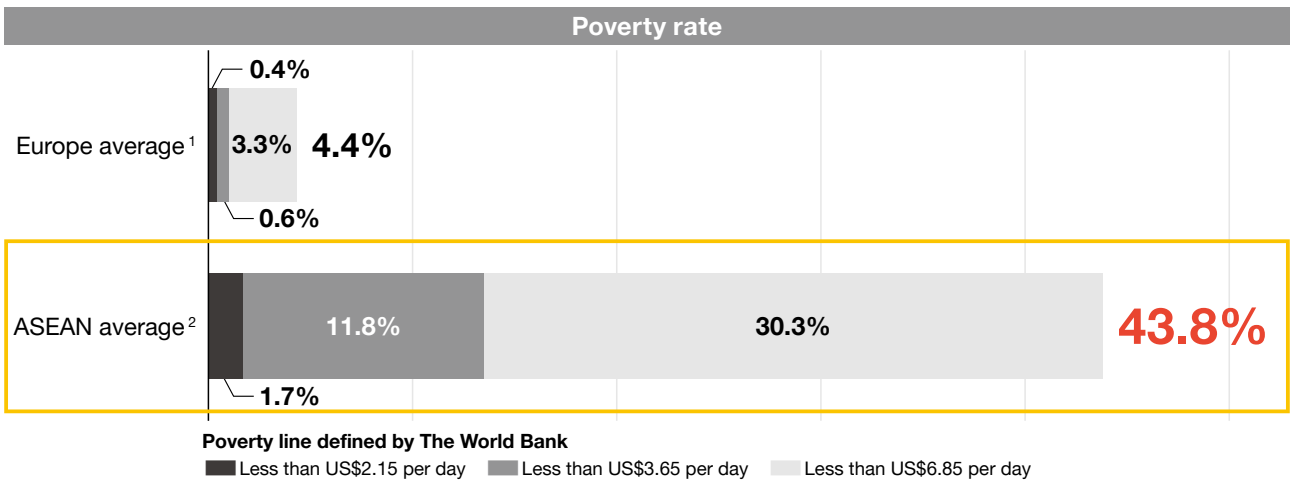


Note: ASEAN includes Indonesia, Thailand, Malaysia, the Philippines and Vietnam; Europe includes Germany, France, Italy, Spain, Poland and the Netherlands only; the figures are the sum of each country's GDP.

Left: Data compiled by PwC based on The World Bank, 'Population estimates and projections' (https://databank.worldbank.org/source/population-estimates-and-projections). Accessed October 2023.

Right: PwC (2017), 'The World in 2050 – The Long View: How will the global economic order change by 2050?' (https://www.pwc.com/gx/en/research-insights/economy/the-world-in-2050.html)

The percentage of the population living below the poverty line, as defined by the World Bank, reveals significant disparity. While the average for Europe is 4.4%, the ASEAN average is notably higher at 43.8%. The prevalence of people living below the poverty line in ASEAN emphasises a pressing necessity for future economic growth in the region.



[1] Average of 42 out of 46 Council of Europe member states as of October 2023, excluding Liechtenstein, San Marino, Andorra and Monaco, for which no data is available (weighted average value taking population into account).

[2] Average based on the latest data from 6 of the 10 ASEAN member countries as of October 2023, excluding Cambodia, Singapore, the Philippines and Brunei, for which no data is available (weighted average after taking population into account).

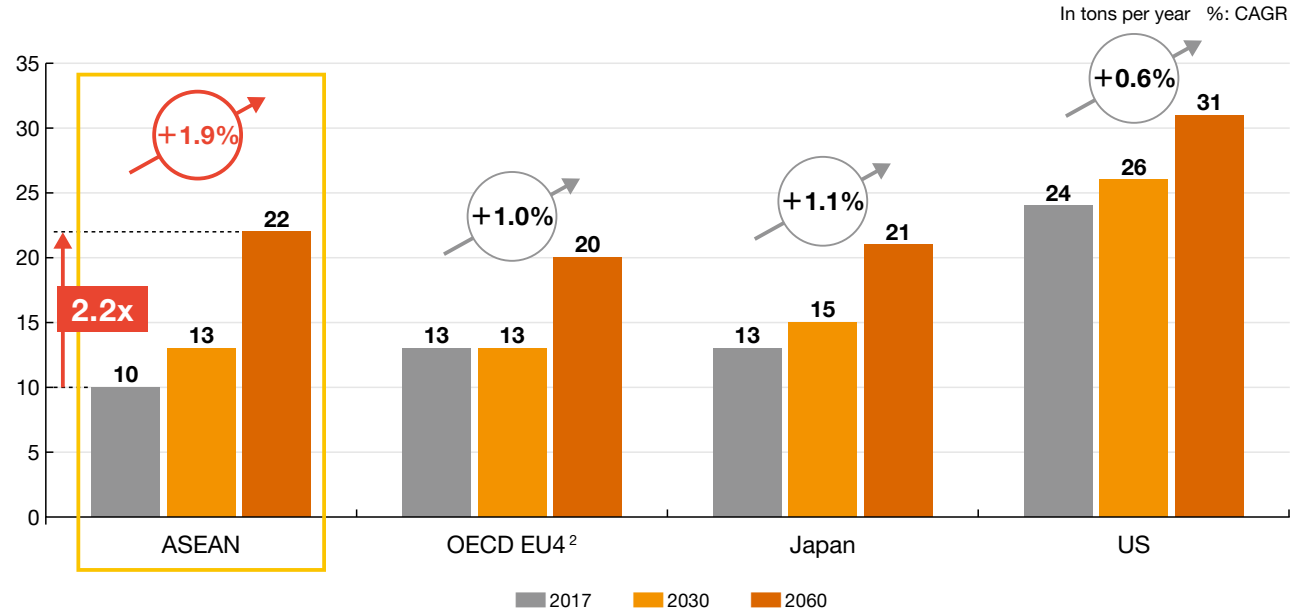
Chart: Data compiled by PwC based on THE WORLD BANK, 'Poverty and Inequality Platform' (https://pip.worldbank.org/home). Accessed November 2022.
Council of Europe member states: Ministry of Foreign Affairs, 'Council of Europe' (https://www.mofa.go.jp/mofaj/area/ce/index.html). Accessed November 2022.

(2) Forecasts indicate increasing resource use and waste in ASEAN

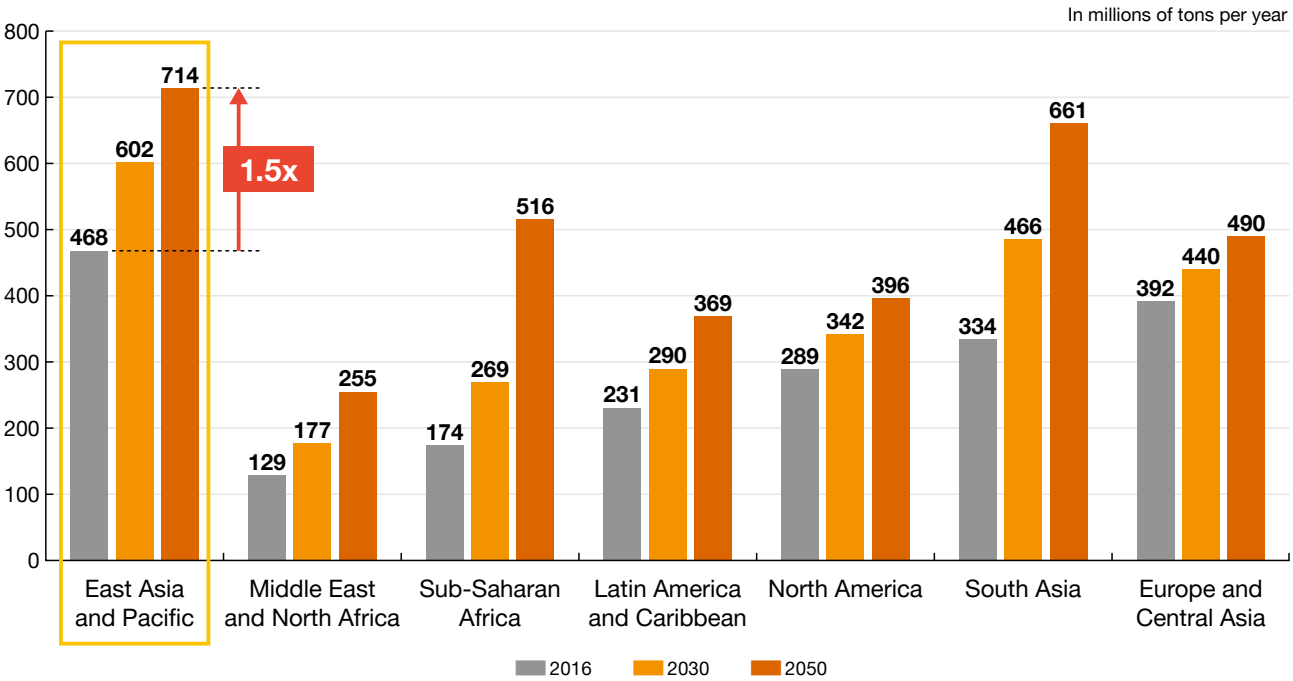
The second point is an increase in resource usage and waste. In ASEAN countries, per capita resource usage is expected to increase by 1.9% annually to 22 tons by 2060, doubling the amount from 2017.

Municipal waste per capita in the East Asia-Pacific region, including ASEAN countries, is expected to increase from 468 million tons per year in 2016 to 714 million in 2050, an increase by a factor of 1.5.

Projected resource use per capita[1]



Projected municipal solid waste generation



[1] Resource use per capita is calculated by dividing the resource use of each country proportionally by the population in the relevant year. The population projection of 2050 was used as an alternative for 2060.

[2] OECD EU4: France, Germany, Italy and the United Kingdom

Left (Resource use): Data compiled by PwC based on OECD (2019), Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences, (https://doi.org/10.1787/9789264307452-en)

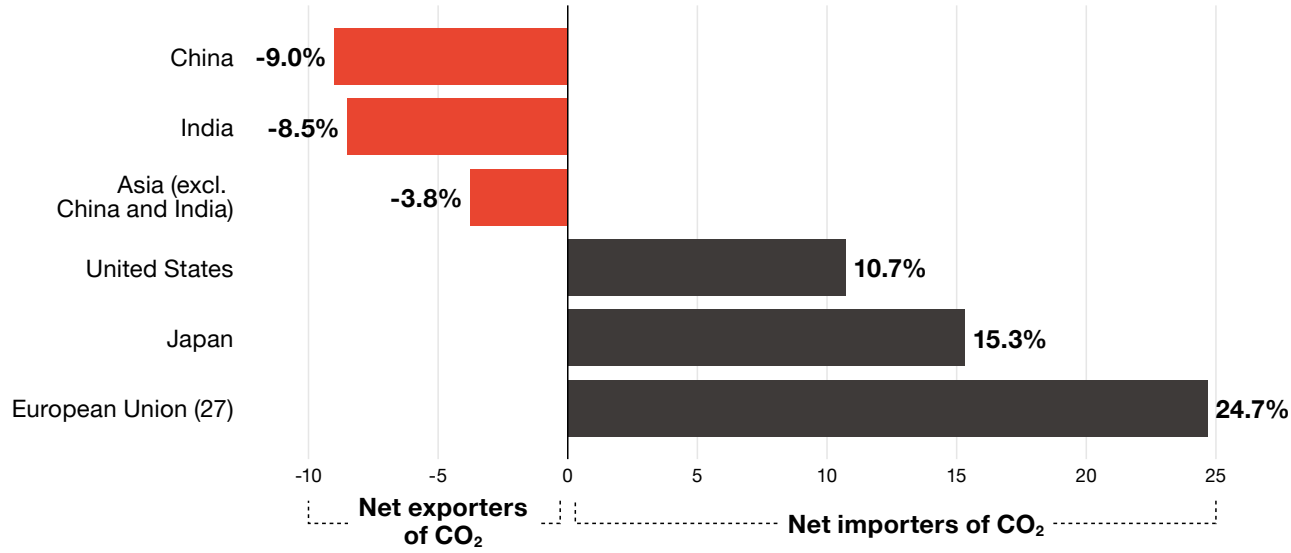
Left (Population data): THE WORLD BANK, 'Population estimates and projections' (https://databank.worldbank.org/source/population-estimates-and-projections). Accessed October 2023.

Right: Data compiled by PwC based on WORLD BANK GROUP (2018), 'What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050' (https://openknowledge.worldbank.org/entities/publication/d3f9d45e-115f-559b-b14f-28552410e90a)

(3) ASEAN's role as a manufacturing hub and waste disposal site for developed countries

ASEAN serves as a base for various manufacturers and suppliers, playing a key role in the global network of manufacturing. Examining the balance of CO_2 exports and imports by country shows that countries in Asia, including ASEAN, are responsible for the CO_2 emissions of developed countries. In other words, Asian countries shoulder the burden of CO_2 emitted in the manufacturing process of goods consumed all over the world.

Share of CO_2 emissions embedded in trade (2021)



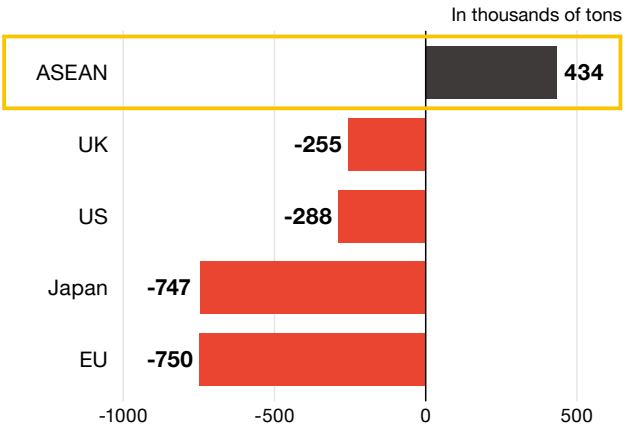
Data compiled by PwC based on Global Carbon Budget (2023) – with major processing by Our World in Data. Share of CO_2 emissions embedded in trade [dataset]. Global Carbon Project, Global Carbon Budget [original data]. Retrieved December 19, 2023 from https://ourworldindata.org/grapher/share-co2-embedded-in-trade

Meanwhile, ASEAN countries also play the role of a global waste disposal site. In addition to their own domestically generated waste, these countries are used as waste disposal sites for developed nations.

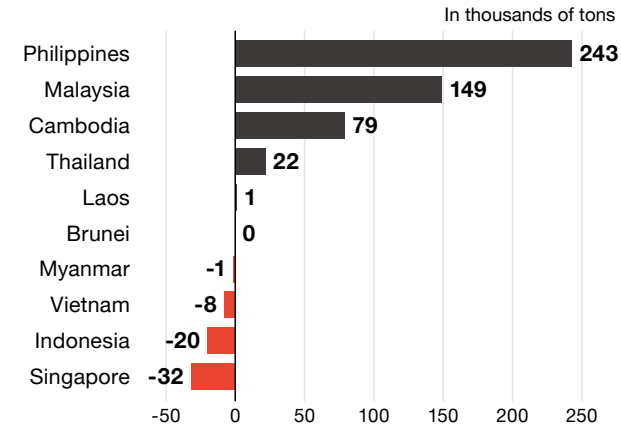
In terms of import/export balances (imports minus exports) of waste for final disposal, ASEAN is a net importer with a balance of 434,000 tons (imports greater than exports), while developed countries, led by Europe and Japan, are net exporters (imports less than exports). The difference is significant. The net exports of Europe and Japan totalled 750,000 tons and 747,000 tons respectively.

Among ASEAN countries, the Philippines (net imports of 243,000 tons) and Malaysia (net imports of 149,000 tons) are the largest importers of waste.

Final waste[1] trade balance (imports - exports, 2019)[2]



Final waste trade balance for ASEAN countries (imports - exports, 2019)



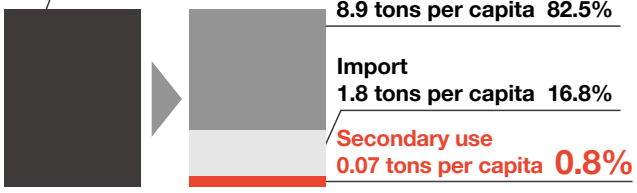
[1] 'Waste for Final Treatment and Disposal' from the following source.
[2] Please note that global waste balance may not be ±0 as definitions and measurement methods may differ between countries and regions.
Data compiled by PwC based on United Nations Environment Programme (UNEP) 'Global Material Flows Database' (https://www.resourcepanel.org/global-material-flows-database). Accessed 15 May 2023.

(4) Resource reuse and recycling is still maturing

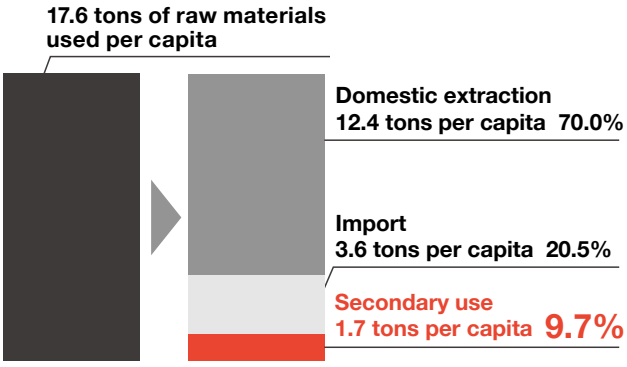
In ASEAN, resource reuse is still maturing, and overall, recycling is not advancing. In fact, a significant amount of waste is openly dumped, causing severe challenges.

The material flow analysis demonstrates the amount of raw materials and secondary materials used per capita as an indicator of the circularity rate of end-of-life waste. These figures show that most ASEAN countries primarily source virgin material domestically or import it, with secondary use (input from resource recovery and recycling) accounting for only 0.8% of the total, considerably less than the 9.7% rate of the EU.

Material flow across ASEAN



Material flow across EU



* Note that the figures for ASEAN are for 2018 and those for the EU are for 2021.

Left: Data compiled by PwC based on Emami N, Schandl H, West J (2022) 'Material Flow Analysis for ASEAN economies' CSIRO, Australia. (https://research.csiro.au/sruap/material-flow-analysis-and-the-state-of-circularity-in-asean-economies/).

Right: Data compiled by PwC based on Eurostat 'Material flow diagram' (https://ec.europa.eu/eurostat/cache/sankey/circular_economy/-sankey.html?geos=EU27&year=2021&unit=THS_T&materials=TOTAL&highlight=0&nodeDisagg=0101100100&flowDisagg=false&language=EN&material=TOTAL). Accessed 15 May 2023.

In addition, ASEAN has few formal players responsible for waste and resource collection. For example, although reports show 148 companies in Thailand hold permits to recycle electronic waste (e-waste), which is relatively high among ASEAN countries, the number of Thai operators in the informal sector (e.g. junk shops) may exceed 9,000. Resource collection is therefore centred around the informal sector in ASEAN.

Number of authorised e-waste recycling operators and the status of collection

Country	Number of authorised e-waste recycling operators/factories
Thailand	**148**
Malaysia	141
Philippines	48
Vietnam	43
Indonesia	8

Collection of household e-waste in Thailand

- There are overwhelmingly more informal sector operators (junk shops, demolition companies and others) and most collection comes from purchases by these operators

Number of authorised operators	**148**
Number of operators in the informal sector (e.g. junk shops)	**9,000+**

- Waste pickers who visit households and collect e-waste for free
- Charities and temples that fulfil the role of collection centres and collect e-waste for free

Left: Data compiled and translated by PwC based on Ministry of Economy, Trade and Industry (2019)「アジアにおける国際資源循環型リサイクル事業拡大に向けた調査報告書」(Report on Growth of International Circular Resource Recycling Projects in Asia). (https://www.meti.go.jp/meti_lib/report/H30FY/000290.pdf)

Right: Data compiled and translated by PwC based on JICA (2014)「アジア地域 マレーシア及び近隣国E-waste管理に関する情報収集・確認調査」(Information gathering and confirmation survey on E-waste management in Asia, Malaysia and neighboring countries). (https://openjicareport.jica.go.jp/618/618/618_113_12154571.html)

As explained above, in ASEAN, not only is there an increase in domestic resource utilisation and waste due to population growth and economic expansion, but the region also holds significant responsibility as a global manufacturing hub and waste disposal site, carrying the burden of resource consumption, CO_2 emissions, and waste disposal. Given the uncertainty and rising costs of virgin resources due to resource depletion and geopolitical risks, reusing ASEAN waste resources in the manufacturing cycle and creating a circular economy (CE) is critical from both sustainability and business perspectives.

2. Current situation and challenges towards achieving a circular economy in major ASEAN countries

	Economic characteristics	Current situation and challenges
Material circularity	• Minerals: High economic rationale for circularisation; high residual value. • Plastics: Low economic rationale for circulation, but high societal demand.	• ASEAN serves as the world's manufacturing hub and waste disposal site, utilising numerous internal and external resources to support global consumption, whilst also importing waste from developed countries. • As the region's population and economy grow, both material demand and subsequent disposal will rise. • Due to inadequate waste management infrastructure, domestic and imported waste cannot be used effectively as input for manufacturing.
Bio-circularity	Low economic rationale for circulation, but it is the basis for human survival.	• The increasing demand for food and commodities (palm oil etc.) both domestically and globally is intensifying and results in (1) deforestation from land modification practices such as slash-and-burn agriculture and (2) soil contamination and degradation due to widespread nitrogen fertilisers. • Adoption of sustainable agricultural methods that do not rely on slash-and-burn or nitrogen fertilisers is essential.
Carbon circularity	Low economic rationale for circulation, but significant societal demand.	• Along with China, ASEAN is the world's manufacturing hub, using significant amounts of energy to support global consumption and bearing responsibility for global GHG emissions. • ASEAN energy demand is expected to increase alongside economic growth. • Due to limited availability of renewable resources and development of relatively new coal-fired power plants, outlining a clear path for energy transition is not easy. • In ASEAN, 6.6% of GHG emissions come from manufacturing, 12.3% from agriculture and 29.2% from land modification and forest fires. Promoting material circularity and bio-circularity offers a broad scope to contribute to carbon circularity. In the EU, manufacturing accounts for 5% of overall GHG emissions, highlighting ASEANS significant role as the world's manufacturing hub. See p.14 'Share of CO_2 emissions embedded in trade (2021)'

Up to this point, this report has examined the importance of promoting a circular economy in ASEAN. However, it is important to specifically address the necessity of pursuing (1) material circularity, (2) bio-circularity and (3) carbon circularity. The goals of each are as follows.

(1) **Material circularity**: Minimising the extraction and diffusion of resources by circulating minerals and plastics
(2) **Bio-circularity**: Realising sustainable agriculture with a focus on minimising nitrogen extraction and diffusion
(3) **Carbon circularity**: Achieving carbon neutrality by minimising carbon extraction and diffusion

Advancing these three circularities requires a proper grasp of the current situation and challenges in ASEAN. However, we will first examine the economic rationale of circularity.

(1) For material circularity, many mineral resources have a particularly high residual value, providing economic rationale for recycling and reuse. Plastics were previously considered a material with low economic rationale, but market expansion and introduction of regulations are slowly creating economic rationale for certain types of plastics. (2) Bio-circularity occurs naturally when substances circulate harmoniously, but human economic activity has broken the cycle. For businesses, restoring the bio cycle is difficult to rationalise economically, but maintaining the natural cycle is essential for human survival, and social demands and pressures on business are gradually growing. (3) Carbon circulation does not mean that, for example, carbon dioxide itself has economic value and that there is economic rationale for its reuse. However, recognising that a major disruption of the carbon cycle causes climate change, society is now exploring mechanisms, like those used for plastics, to create economic rationale by introducing regulations such as carbon taxes.

Based on the above information, this report considers the current situation and challenges for each of the three circularities.

We will first discuss material circularity. As stated earlier, ASEAN is the world's manufacturing hub and waste disposal site. The countries concerned use many resources and handle waste disposal to support not only local consumption but global consumption, too. Meanwhile, forecasts indicate that material consumption and waste in the region will increase as populations and economies grow. However, because of the current insufficient waste disposal infrastructure, environmental destruction and social issues are becoming apparent. Additionally, 55% of the world's marine plastics flow out of ASEAN countries, with the Philippines as the world's largest emitter. This presents a huge environmental problem.

Given the rising prices and uncertain availability of virgin resources due to resource depletion and geopolitical risks, there is a growing need for ASEAN countries—where many companies have manufacturing bases—to appropriately collect, recycle, and reuse this waste as a resource. However, the region has yet to develop a sufficient recycling infrastructure, so these resources are not properly utilised.

Next, let's consider bio-circularity. The population of ASEAN is growing at an alarming rate and the region has become a producer of global commodities like palm oil. There are two significant problems: (1) nitrogen pollution and soil degradation from nitrogen fertilisers required to meet local and global demand and (2) significantly worsening deforestation due to land modification using methods like slash-and-burn. Restoring bio-circularity will require the adoption of appropriate sustainable farming methods that do not rely on nitrogen fertilisers or slash-and-burn agriculture.

Lastly, let us examine carbon circularity. Forecasts show that ASEAN countries will experience significant economic growth, and energy demand is expected to continually rise. Ideally, these energy needs would be met with renewable energy, but ASEAN countries have relatively few renewable energy sources compared to other regions. In addition, many countries have relatively new coal-fired power plants, and the economic constraints make it difficult to decommission them immediately.

Meanwhile, 6.6% of ASEAN's CO_2 emissions come from manufacturing, 12.3% from agriculture and 9.2% from land modification and forest fires. Consequently, the advancement of material and bio-circularity, as mentioned above, will also assist carbon circularity. Dependence on fossil fuel energy is a major problem for the ASEAN region, but it is also an area which is difficult for a single company to change. On the other hand, there are many other important areas for ASEAN upon which private companies can take swift measures to promote carbon circularity. First, ASEAN must identify and promote 'low-hanging fruits'—areas or challenges that are relatively easy to tackle—to progress towards carbon circularity.

The following section provides a detailed description of challenges for each of the three circularities.

Current situation and challenges for material circularity

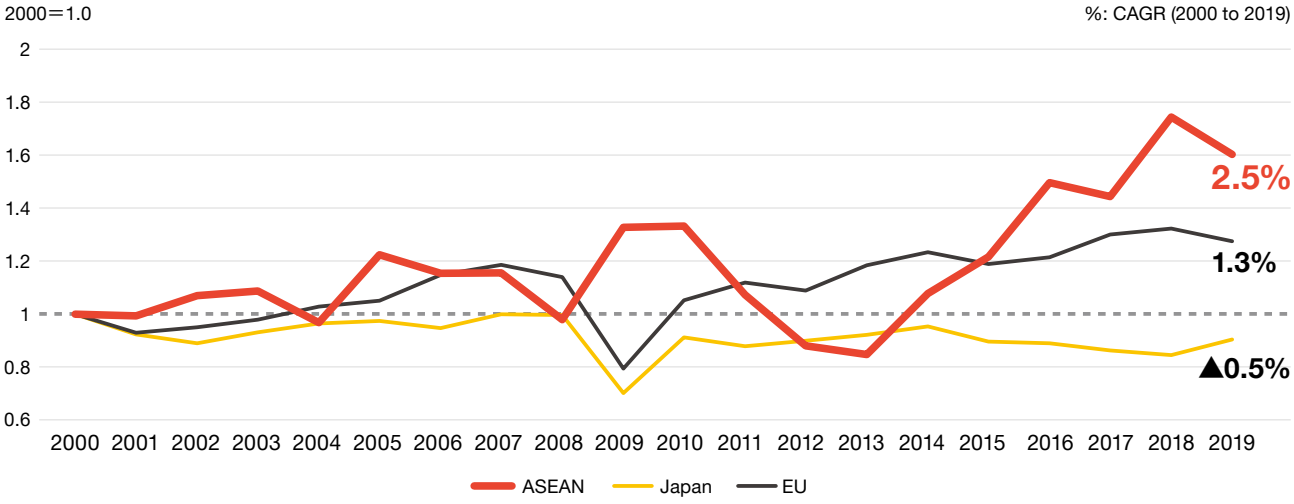
Inputs and outputs

As mentioned above, both resource use and waste are expected to increase in ASEAN.

Data on mineral resource input shows that domestic material consumption (domestic extraction + imports - exports) of iron ore and non-ferrous ores (including rare metals) has increased by 2.5% annually over the 20 years since 2000. By comparison, consumption in the EU increased by 1.3% and decreased by 0.5% in Japan.

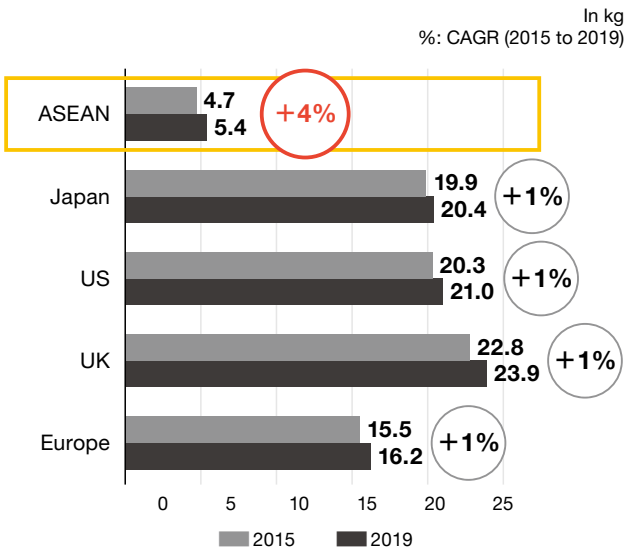
Data on output indicates that per capita generation of e-waste in ASEAN was 5.4 kg in 2019, 4% higher than 2015. This rate of increase is conspicuous compared to the 1% increase across all developed nations, including Japan and the US. In addition, the number of end-of-life vehicles will increase at a rate of 6% annually from 2017 to 2050.

Domestic material consumption (DMC)[1] of minerals[2]

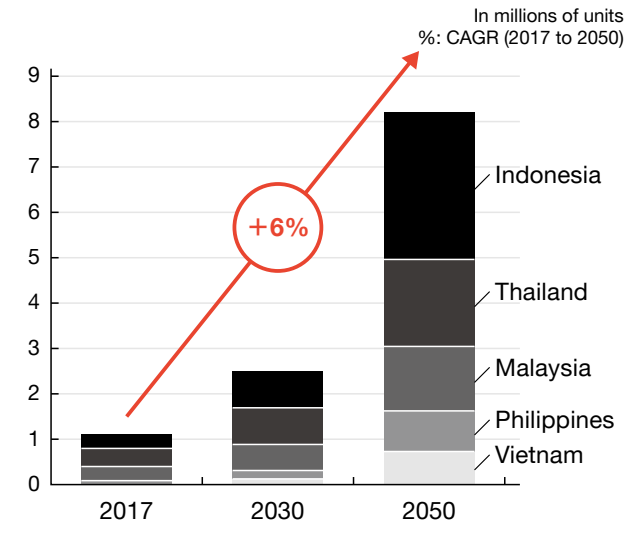


[1] DMC: domestic material consumption = domestic extraction + imports – exports
[2] Iron ore, non-ferrous ore
Data compiled by PwC based on Chatham House (2021) 'resourcetrade.earth' (https://resourcetrade.earth//). Accessed 15 May 2023.

E-waste per capita



Number of End-of-Life Vehicles (ELV)

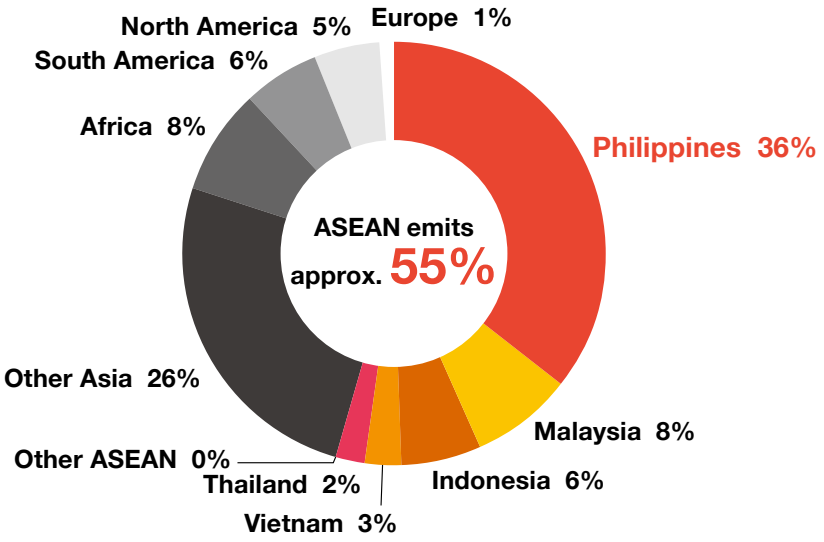


Left: Data compiled by PwC based on Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann,P.(2017) 'The Global E-waste Monitor', United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna. (https://globalewaste.org/).
Right: Data compiled and translated by PwC based on Ministry of Economy, Trade and Industry (2019)「アジアにおける国際資源循環型リサイクル事業拡大に向けた調査報告書」(Report on Growth of International Circular Resource Recycling Projects in Asia). (https://www.meti.go.jp/meti_lib/report/H30FY/000290.pdf)

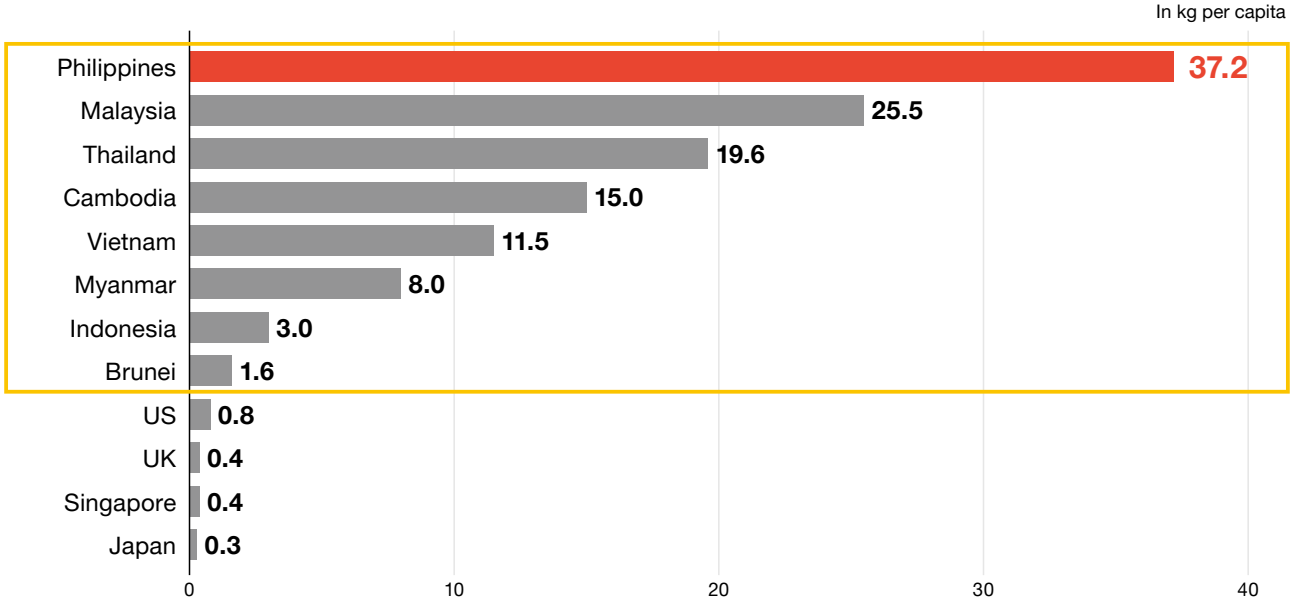
An estimated 55% of the world's annual marine plastic waste come from ASEAN countries. The Philippines is the world's largest emitter of plastic, accounting for 36% of the total. Inadequate management of plastic waste is a common challenge across ASEAN.

The Pasig River, which flows through the Philippines' capital Manila, is considered the world's largest source of plastic waste. Reports indicate that only two plant species and six species of fish remain in the river due to plastic waste severely damaging the ecosystem [1]. This waste often flows into the ocean from small rivers in densely populated urban areas, which necessitates proper management to prevent waste from flowing from land to rivers.

% of global plastics emitted to the ocean (2019) [2]



Mismanaged plastic waste (2019) [3]



[1] UNEP, WHO, and Water Supply & Sanitation Collaborative Council (1997). 'Water Pollution Control - A Guide to the Use of Water Quality Management Principles'. (https://wedocs.unep.org/20.500.11822/33367).

[2] Projections of waste plastic based on macroeconomic dynamics such as population and economic growth also include geographical factors (topography, weather conditions, rivers, etc.)

[3] Mismanaged plastic waste refers to plastics that are scattered or disposed of improperly. Exports to overseas are not included.

Data compiled by PwC based on Hannah Ritchie and Max Roser, (2018). 'Plastic Pollution'. Published online at OurWorldInData.org. (https://ourworldindata.org/plastic-pollution). Accessed 15 May 2023.

Disposal of waste resources

In many ASEAN countries, unlicensed illegal recyclers (informal sector and personal recycling activities) are pivotal in disposing of material outputs. However, this causes various problems.

Environmental pollution is one such issue. Informal operators use hazardous chemicals to recover gold and silver from substrates and palladium from cables, contributing to environmental pollution in local communities. According to a World Health Organization (WHO) report, many women and children are engaged in the informal sector, which is correlated with health hazards such as exposure of workers to toxic substances.

Environmental pollution	• Informal operators use hazardous chemicals (such as sulfuric acid) to recover gold, silver and palladium from substrates and cables. This contributes to environmental pollution through leachate and vapour (generated when separating valuable metals and impurities from leachate), which contain harmful substances.
Health hazards	• **Workers** without appropriate safety knowledge may be exposed to toxic substances and **local residents** may face serious health damage, particularly from leachate. Note: According to WHO research, 12.9 million women and more than 1,800 children work in the informal waste sector globally. Studies show that exposing pregnant women to lead from e-waste recycling activities significantly decreases behavioural neurology assessment scores in newborns, raises rates of attention deficit/hyperactivity disorder (ADHD) and behavioural problems and reduces cognition and language skills.

Environmental pollution: Data compiled and translated by PwC based on Ministry of Economy, Trade and Industry (2019)「アジアにおける国際資源循環型リサイクル事業拡大に向けた調査報告書」(Report on Growth of International Circular Resource Recycling Projects in Asia). (https://www.meti.go.jp/meti_lib/report/H30FY/000290.pdf)

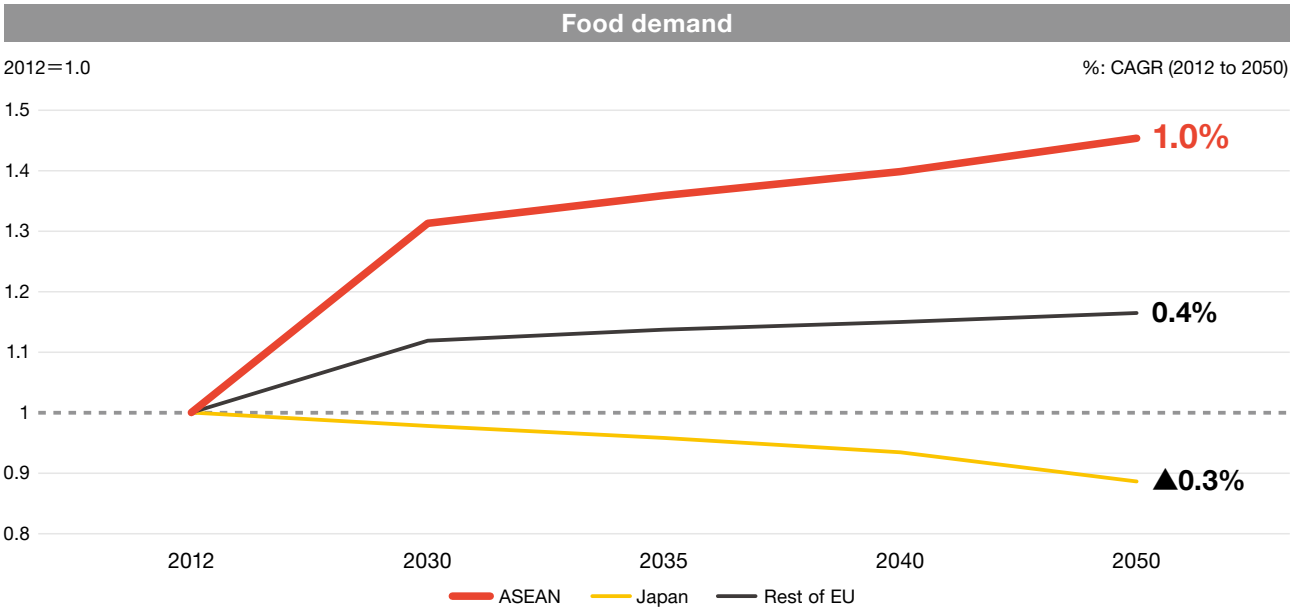
Health hazards: WHO 'Soaring e-waste affects the health of millions of children' (https://www.who.int/news/item/15-06-2021-soaring-e-waste-affects-the-health-of-millions-of-children-who-warns). Accessed 15 May 2023.

Current situation and challenges for bio-circularity

Food demand

With the increase in population and economic growth, ASEAN is expected to see a continued rise in food demand. The forecasted growth rate of food demand from 2012 to 2050 is 0.4% annually for the EU, a decrease of 0.3% for Japan, while ASEAN is anticipate to have a growth rate of 1.0%, necessitating increased food production.

Further, ASEAN countries are responsible for producing commodities such as palm oil to meet international needs.



Data compiled by PwC based on FAO (2018) 'The future of food and agriculture – Alternative pathways to 2050' Rome. (https://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/)

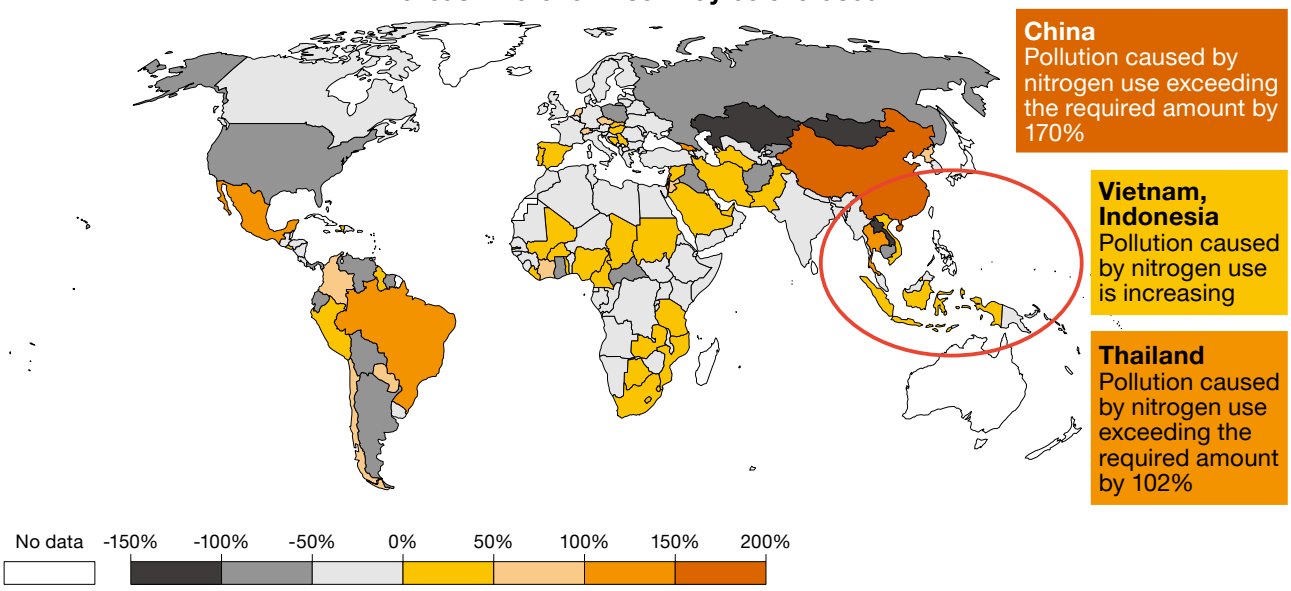
Nitrogen pollution

Nitrogen is one of the main components of chemical fertilisers, and some farmers are overapplying fertiliser to improve yield, which is contributing to nitrogen pollution. Examining the issue by country reveals that, while nitrogen pollution is a serious problem in China, ASEAN countries, particularly Thailand, are experiencing an increasing problem of pollution from excessive nitrogen use. Vietnam and Indonesia also show tendencies of pollution. There is considerable room for these regions to adopt sustainable farming methods, minimising the use of fertilisers.

Incidentally, the use of chemical fertilisers is on the rise globally. Indonesia is the heaviest user of chemical fertilisers in ASEAN, accounting for about 40% of ASEAN usage.

Nitrogen pollution status

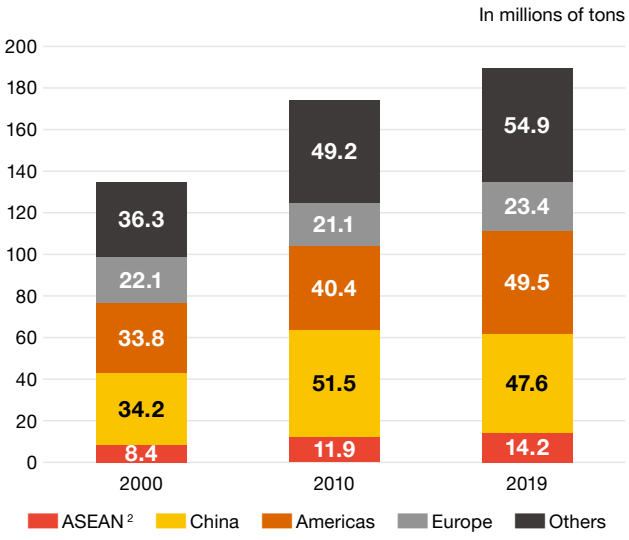
Countries with positive values use more nitrogen than needed to increase yield, i.e., areas where fertiliser may be overused.



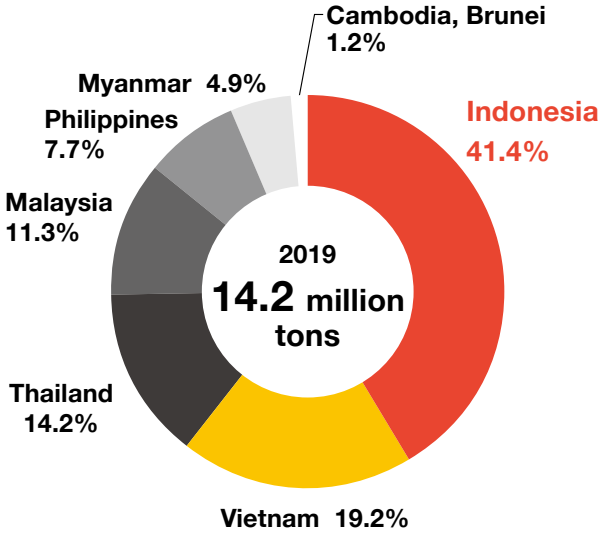
Note: The image shows how much nitrogen pollution countries caused compared with how much they reduced their yield gaps relative to directly neighboring countries. Positive values indicate a country overapplied nitrogen without gains in yield.

Data compiled by PwC based on Hannah Ritchie 'Which countries overapplied nitrogen without gains in crop yields' Published online at OurWorldInData.org (https://ourworldindata.org/reducing-fertilizer-use). Accessed 15 May 2023.

Global chemical fertiliser usage [1]



ASEAN breakdown



[1] $N + P_2O_5 + K_2O$
[2] 8 ASEAN countries excluding Singapore and Laos

Data compiled by PwC based on FAO (2022) FAOSTAT 'Fertilizers by Nutrient' In: FAO. Rome (http://www.fao.org/faostat/en/#data/RFN https://doi.org/10.4060/cc2211en-fig17). Accessed 15 May 2023.

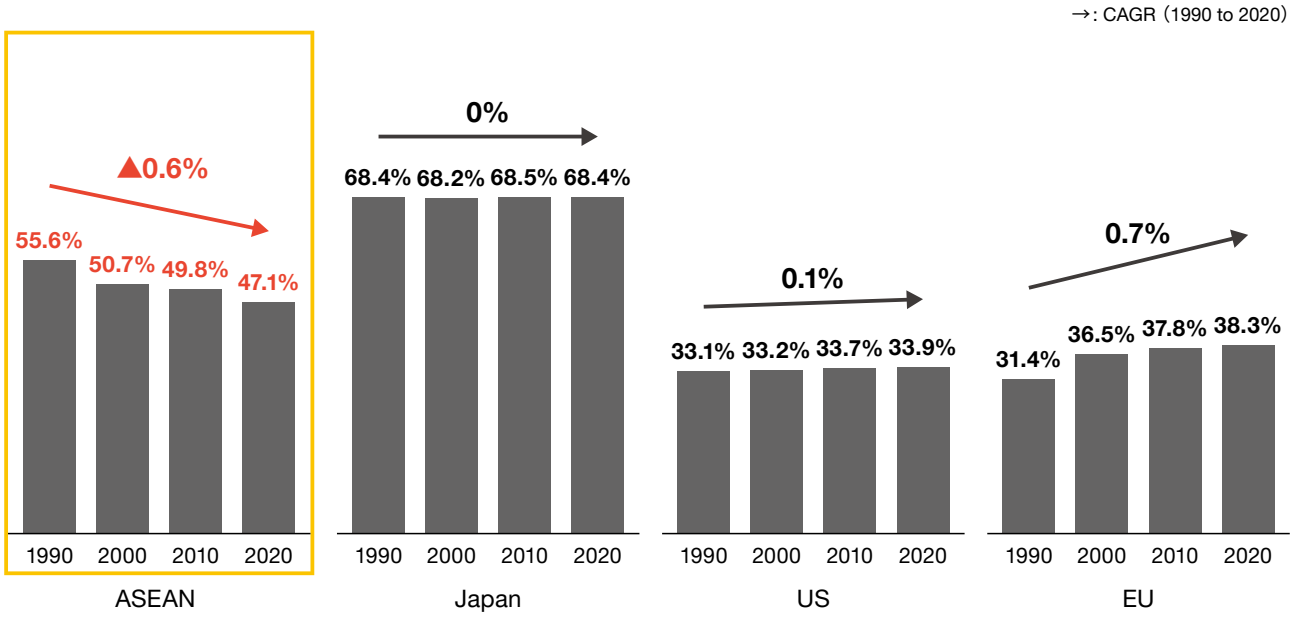
Deforestation

Agricultural problems also lead to other forms of deforestation. In ASEAN, forest area has shrunk by 0.6% per annum over the past 30 years to 2020 due to expanding palm oil production and agriculture. The forest-to-national-land-area ratio fell from 55.6% in 1990 to 47.1% in 2020. During this period, forest area ratios in Japan and the US have remained stable, while the ratio for the EU has increased at an annual rate of 0.7%.

Upon examining the causes of deforestation, commodity-driven deforestation is particularly conspicuous in ASEAN. In short, a major factor is the permanent conversion of forests into land for agricultural (including for palm oil production and livestock breeding), mining and energy infrastructure uses.

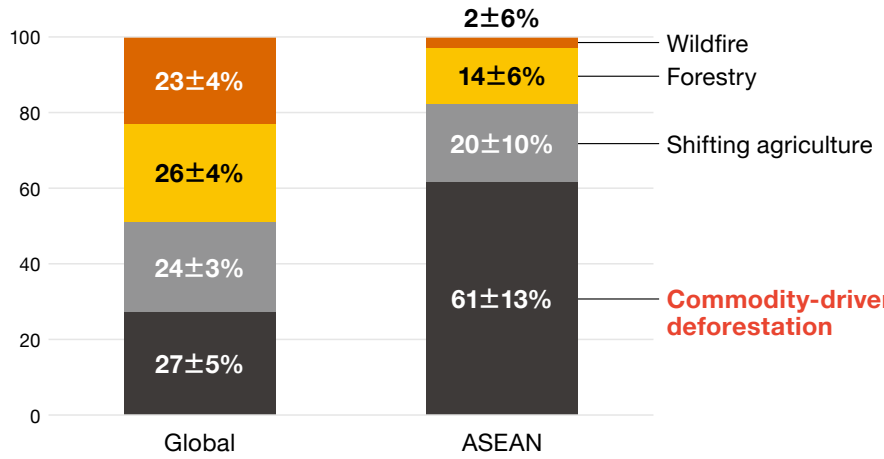
Deforestation in ASEAN stems not only from the expansion of agriculture to meet regional population growth but also from having to support global commodities.

Percentage of forest area to land (%)



Causes of deforestation

Commodity-driven deforestation* is the main cause of deforestation in ASEAN countries.



* Commodity-driven deforestation, defined by the long-term, permanent conversion of forest and shrubland to a nonforest land use such as agriculture (including oil palm), mining or energy infrastructure.

Percentage of forest area to land: Data compiled by PwC based on Hannah Ritchie and Max Roser, (2021) 'Forests and Deforestation' Published online at OurWorldInData.org (https://ourworldindata.org/forests-and-deforestation). Accessed October 2023.

Cause of deforestation: Data compiled by PwC based on Philip G. Curtis et al. ,'Classifying drivers of global forest loss'. Science361,1108-1111 (2018).DOI: (https://doi.org/10.1126/science.aau3445)

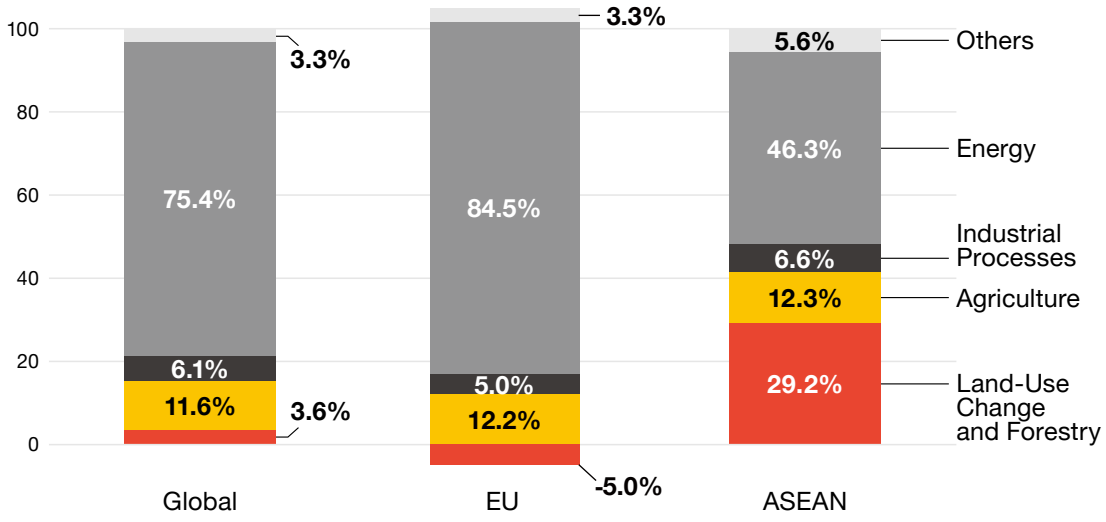
GHG emissions associated with agriculture and deforestation

Agriculture and deforestation also increase GHG emissions. Agriculturally derived GHG emissions is a global challenge, with agriculture and forestry accounting for approximately 15% of all global GHG emissions. By 2050, agricultural GHG emissions are projected to be 1.2 times higher than 2012, making the reduction of these emissions an urgent issue.

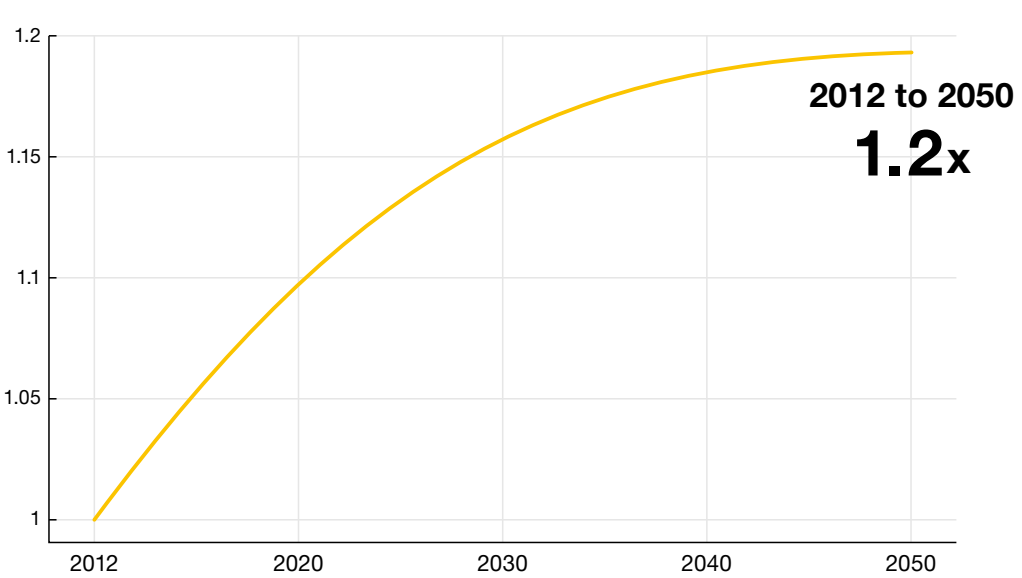
In ASEAN, 12% of emissions originated from agriculture in 2020. However, the share of emissions from land-use change and forestry was extremely high at 29%. GHG emissions from deforestation are caused by burning forests and peatlands to expand farmland; this includes slash-and-burn agriculture. As mentioned earlier, one reason for this is to meet global demand for commodities.

Share of GHG emissions (2019)

- **About 15% of global GHG emissions come from agriculture and forestry**
- **ASEAN countries have particularly heavy forestry-derived emissions at 30%**



Agricultural GHG emissions forecast (global)*



* Of the three scenarios provided by FAO (Business-As-Usual, Stratified Societies and Towards Sustainability), this is the emission prediction for Business-As-Usual.

Share of GHG emissions: Climate Watch Historical GHG Emissions (2022) Washington, DC: World Resources Institute. Available online at: https://www.climatewatchdata.org/ghg-emissions

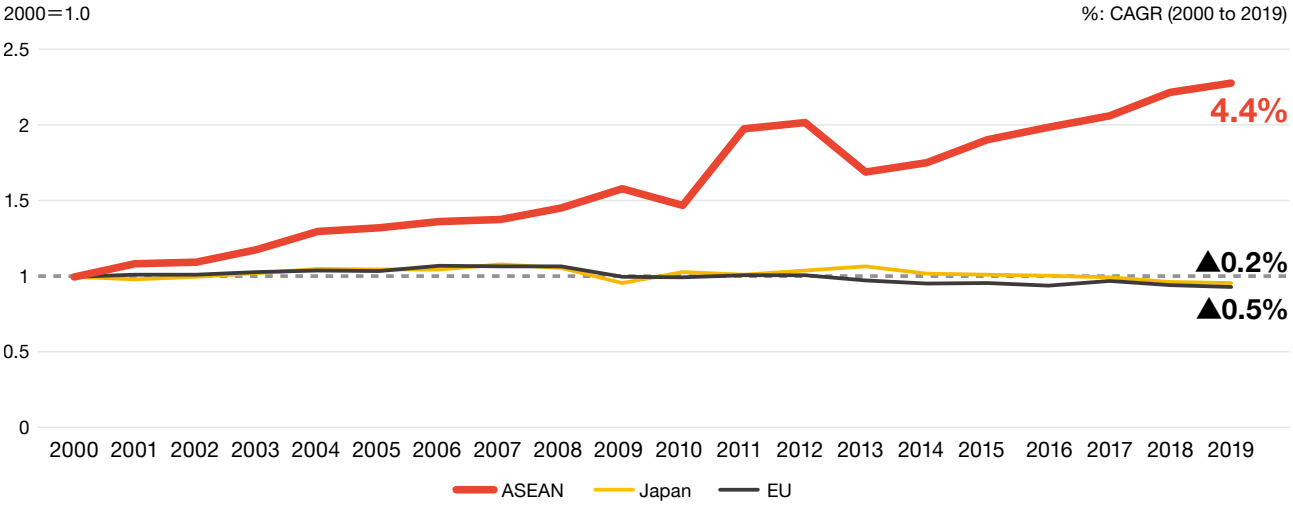
Agricultural GHG emissions forecast (global): FAO (2018) 'The future of food and agriculture – Alternative pathways to 2050' Rome. https://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/

Current situation and challenges for carbon circularity

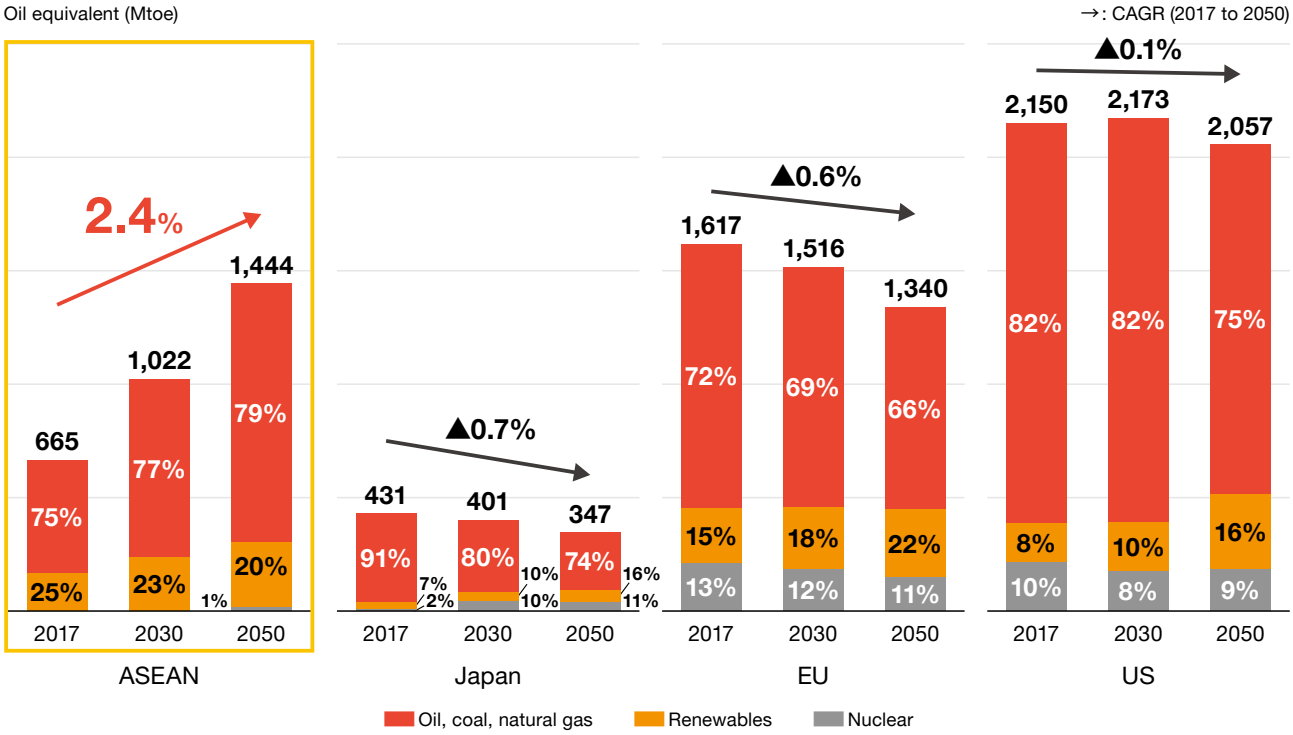
Inputs and outputs

Fossil fuel consumption in ASEAN countries increased by 4.4% annually over the 20 years to 2019. Looking ahead, primary energy use is expected to grow at a rate of 2.4% per annum through 2050. Most of the growing demand is dependent on fossil fuels such as oil, coal and natural gas. As energy consumption in developed countries is expected to decline in the coming years, but expected to increase in ASEAN, ASEAN countries will need to promote energy conservation and introduce renewable energy.

Domestic material consumption (DMC)[1] of fossil fuels[2]



Primary energy use forecast[3]



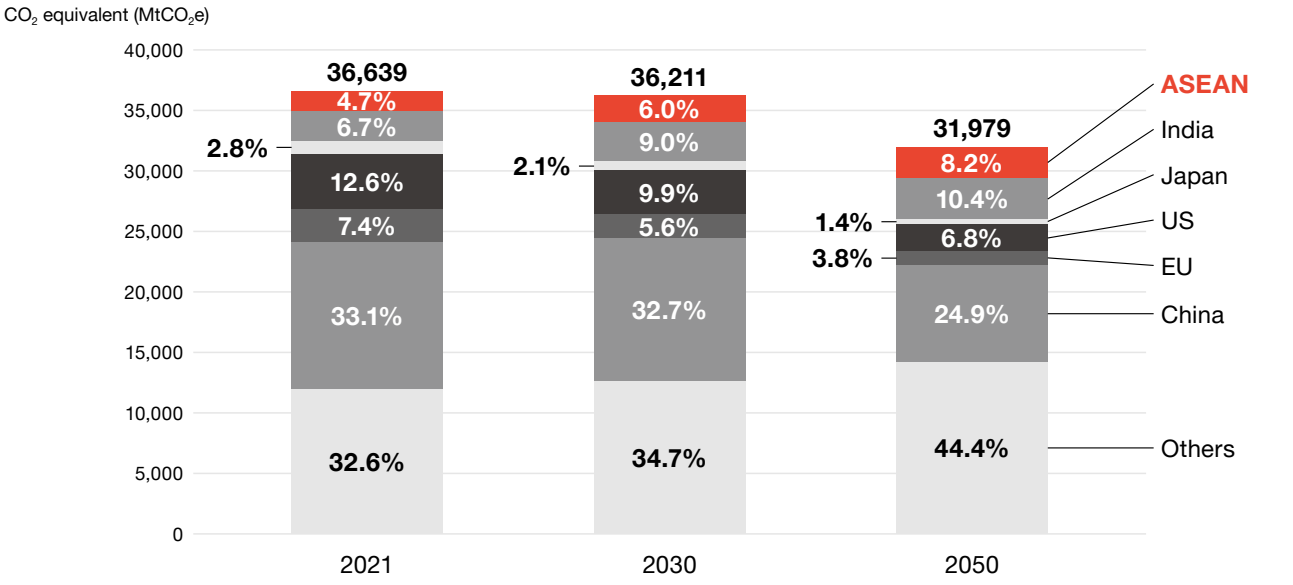
[1] DMC: domestic material consumption = domestic extraction + imports - exports
[2] Coal, oil and natural gas
[3] Exports and imports of electricity, heat and hydrogen are not considered, and the total consumption is calculated by adding up the primary energy consumption of each resource.

Domestic material consumption (DMC) of fossil fuels: Data compiled by PwC based on UNEP 'Global Material Flows Database' (https://www.resourcepanel.org/global-material-flows-database). Accessed 15 May 2023.

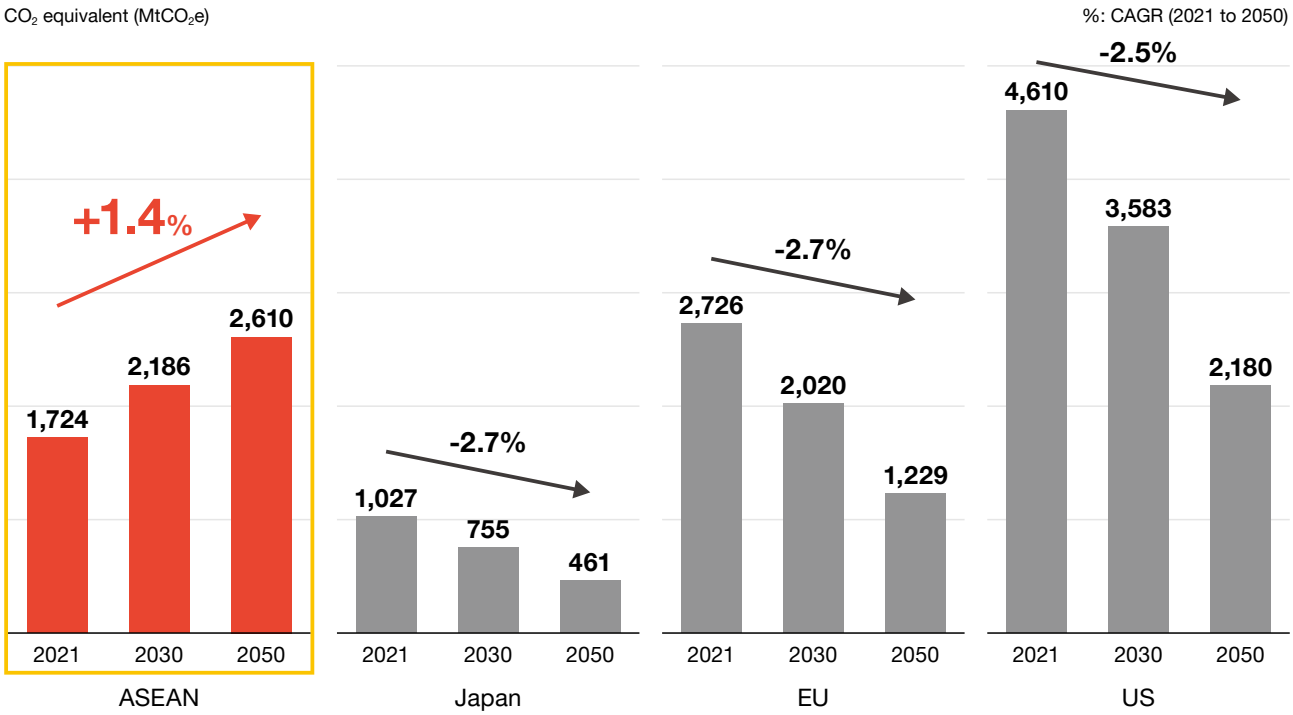
Primary energy use forecast: Data compiled by PwC based on IEEJ (2019)「IEEJ Outlook 2020－深刻化するエネルギートリレンマの克服に向けて」(IEEJ Outlook 2020: Coping with the Increasingly Challenging Energy Trilemma), (https://eneken.ieej.or.jp/data/8644.pdf)

With the increased consumption of energy derived from fossil fuels, projections indicate that CO_2 emissions from ASEAN countries will rise by 1.4% annually through 2050, which is one of the highest growth rates in the world. In comparison, the rate declines by 2.7% in Japan, 2.7% in Europe and 2.5% in the US. As ASEAN countries account for less than 10% of the world's total emissions by country or region, the impact may not be particularly severe. However, since ASEAN emissions will rise while those of other nations decline, immediate action is essential.

Global CO_2 emissions forecast (based on IEA Stated Policies Scenario*)



CO_2 emissions forecast for four regional comparison (based on IEA Stated Policies Scenario*)



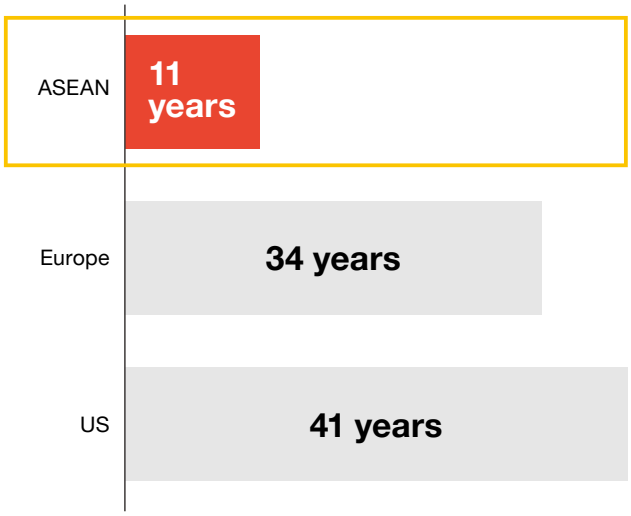
* Stated Policies Scenario (STEPS) by IEA shows the trajectory implied by today's policy settings.
Data compiled by PwC based on IEA (2022) 'World Energy Outlook 2022' IEA, Paris (https://www.iea.org/reports/world-energy-outlook-2022).

One of the factors making decarbonisation difficult in ASEAN countries is that existing coal-fired power plants are relatively new. The average age of coal-fired power plants in Europe and the US is about 30 to 40 years, while it is about 10 years in ASEAN countries. In other words, most ASEAN coal-fired power plants are still depreciating, which makes immediate closure difficult and creates an obstacle for switching to renewable energy.

ASEAN's lack of abundant renewable energy resources is another barrier to decarbonisation in the region. On the maps showing the amount of solar and wind energy resources, dark colours indicate more renewable energy resources, while light colours indicate less. Most ASEAN countries show very few sources of renewable energy.

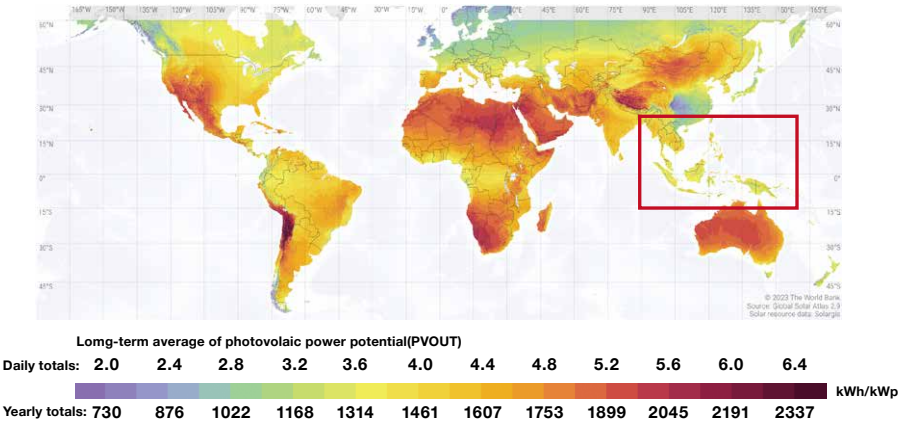
Among the major ASEAN countries, Thailand is relatively rich in solar and wind resources. However, compared to Australia, the US, China and other countries with abundant renewable energy resources, the resources are extremely meagre.

Comparison of average age of coal-fired power plants

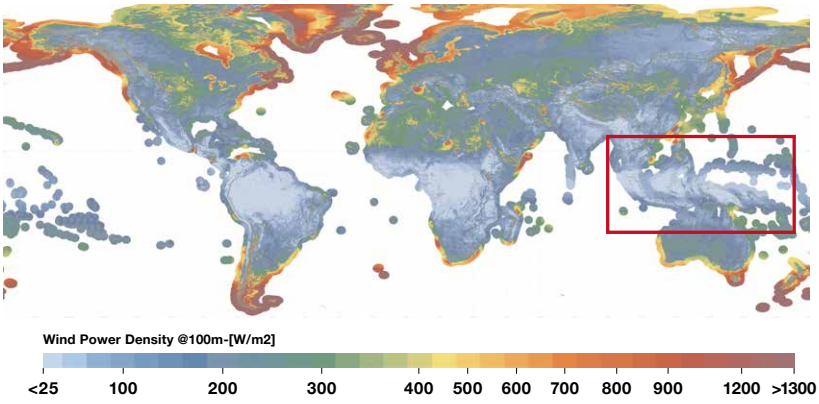


Data compiled by PwC based on IEA (2021) 'World Energy Outlook 2021' IEA, Paris (https://www.iea.org/reports/world-energy-outlook-2021)

Solar resources [1]



Wind resources [2]



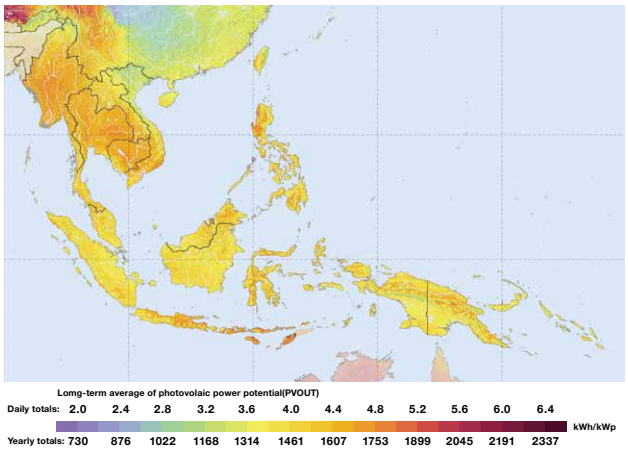
[1] 'Photovoltaic power potential' from the following source [2] 'Power Density Potential' from the following source

Left: WORLD BANK GROUP 'GLOBAL SOLAR ATLAS' 2022. (https://globalsolaratlas.info/download/). Accessed October 2023. Red frame added by PwC. 'Global Solar Atlas 2.0, a free, web-based application is developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilizing Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalsolaratlas.info '

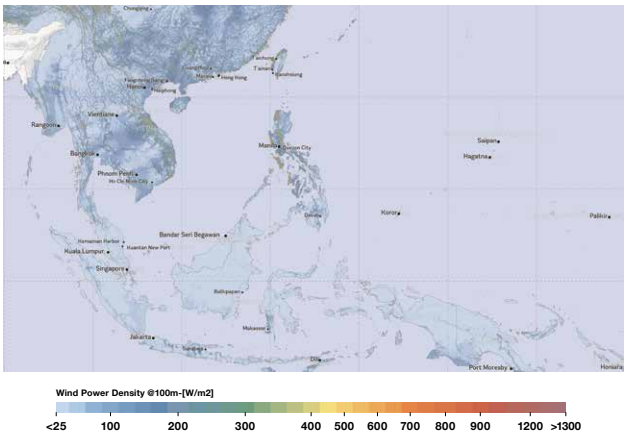
Right: WORLD BANK GROUP 'GLOBAL WIND ATLAS' 2022. (https://globalwindatlas.info/en). Accessed October 2023. Red frame added by PwC. 'Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info '

Distribution of renewable energy resources in ASEAN

Solar

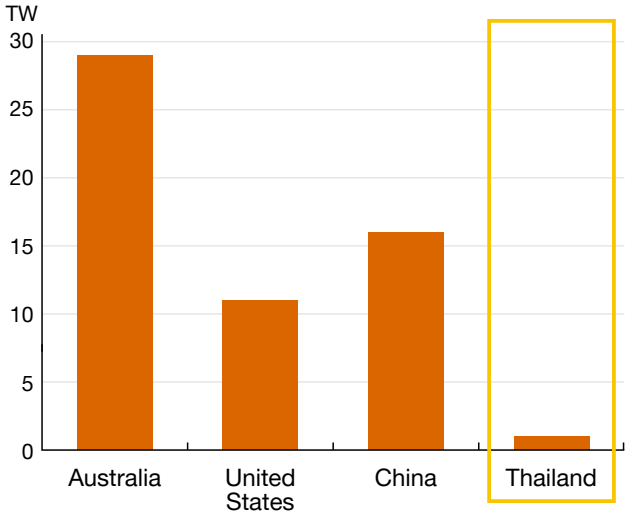


Wind

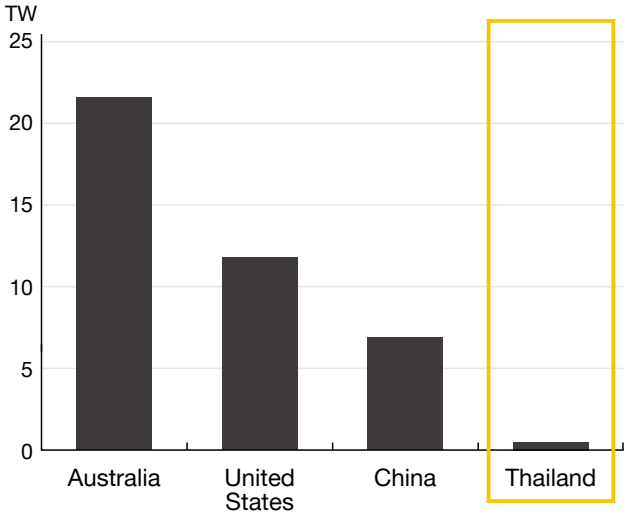


Comparison of distribution of renewable energy resources

Solar



Onshore wind



ASEAN (solar): WORLD BANK GROUP 'GLOBAL SOLAR ATLAS' 2022. (https://globalsolaratlas.info/download/). Accessed October 2023.
'Global Solar Atlas 2.0, a free, web-based application is developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilizing Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalsolaratlas.info '

ASEAN (wind): WORLD BANK GROUP 'GLOBAL WIND ATLAS' 2022. (https://globalwindatlas.info/en). Accessed October 2023.
'Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info '

Data compiled by PwC based on IEEJ (2019)「IEEJ Outlook 2020－深刻化するエネルギートリレンマの克服に向けて」(IEEJ Outlook 2020: Coping with the Increasingly Challenging Energy Trilemma), (https://eneken.ieej.or.jp/data/8644.pdf)

3. Potential business opportunities from promoting a circular economy

Business opportunities of approximately US$10tn globally and US$420bn in ASEAN

So far, this report has examined the macro environment for circularity and the current situation and challenges for promoting the three circularities. However, promoting a circular economy has the potential to create significant business opportunities. According to World Economic Forum (WEF) estimates, nature-positive business opportunities from transitioning to a circular economy are projected to be around US$10tn globally in 2030 or US$420bn when adjusted to the scale of the ASEAN economy.

This includes US$3.565tn from food, land and marine resource use (US$148bn in ASEAN bloc); US$3.53tn from energy and extraction activities (US$146bn in ASEAN bloc); and US$3.15tn from infrastructure and construction environments (US$125bn in ASEAN bloc).

Food, land and ocean use

Global **$3,565bn** ▶ ASEAN * **$148bn**

Energy and extractives

Global **$3,530bn** ▶ ASEAN * **$146bn**

Infrastructure and the built environment

Global **$3,015bn** ▶ ASEAN * **$125bn**

* Estimates based on prorating by GDP. GDP based on IMF forecasts for 2028.

Data compiled by PwC based on World Economic Forum (2020), 'The Future of Nature and Business 2020' (https://jp.weforum.org/reports/new-nature-economy-report-ii-the-future-of-nature-and-business/). This data was not compiled by the World Economic Forum and should not be considered official World Economic Forum data. The World Economic Forum is not responsible for any content or errors.
PwC calculations based on International Monetary Fund, 'GDP, Current Prices' (https://www.imf.org/external/datamapper/NGDPD WEO/OEMDC/ADVEC/WEOWORLD/MEQ/SAQ/SEQ). Accessed October 2023.

Breakdown of nature-positive business opportunities from transitioning to a circular economy

(US$ billion)

Category	Item	Business opportunities	Total
Food, land and ocean use	Ecosystem restoration and avoided land and ocean use expansion	450	3,565
	Productive and regenerative agriculture	1,140	
	Healthy and productive oceans	170	
	Sustainable management of forests	230	
	Planet compatible consumption	1,060	
	Transparent and sustainable supply chains	515	
Energy and extractives	Circular and resource-efficient models	2,310	3,530
	Nature-positive metals and minerals extraction	520	
	Sustainable metals and materials supply chains	30	
	Nature-positive energy transition	670	
Infrastructure and the built environment	Compact built environment	665	3,015
	Nature-positive built environment	935	
	Planet-compatible urban utilities	670	
	Nature as infrastructure	160	
	Nature-positive connecting infrastructure	585	
			Total 10,110

Data compiled by PwC based on World Economic Forum (2020), 'The Future of Nature and Business 2020' (https://jp.weforum.org/reports/new-nature-economy-report-ii-the-future-of-nature-and-business/).
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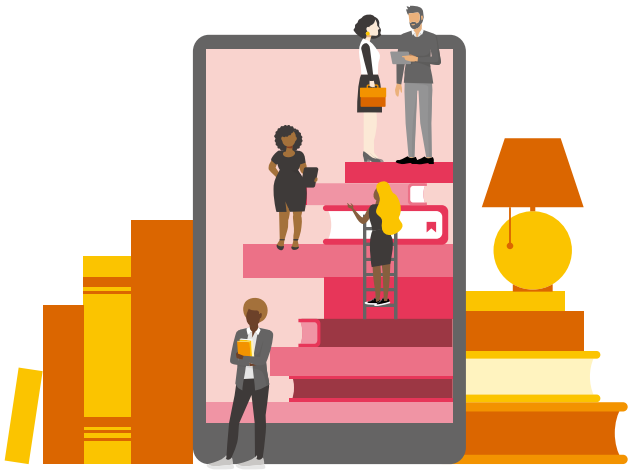
Creating circular economy markets in ASEAN countries

To deepen an understanding of circular economy markets in ASEAN countries, it is crucial to visit these regions and listen to local voices to grasp the actual situation. We visited the region and conducted on-site meetings. As a result, several hypotheses have emerged regarding the direction of circular business, such as collaboration with new players to minimise extraction and diffusion, and deepening collaboration with stakeholders in company value chains. In the future, we will pursue further discussions on the direction of circular business based on these hypotheses.



Afterword

For the 2024 Davos Conference, the Executive Sustainability Forum has announced a joint statement to realise sustainable growth in ASEAN. Discussions for the joint statement were based on the circular frameworks proposed by PwC Japan Group.

With the absence of human economic activity, carbon, minerals, nitrogen, water and other substances would exist in a fixed and balanced state in nature. However, they are extracted and diffused in large quantities for economic purposes, resulting in environmental issues such as resource depletion, ecosystem degradation, climate change, and pollution of the air, water and soil. This model is the basis for modern human economic activity, and unless we change it, it will be difficult to solve environmental issues.

Transitioning to a circular model is essential, and promoting such a model may be the most effective approach to creating a 'trade-on' (opposite of 'trade-off') situation that achieves business growth while reducing environmental and social impacts.

The authors of this report believe that Japanese companies must not only view ASEAN members as a production and consumer base, but they must also become partners for cooperative growth while helping to solve environmental and social issues in ASEAN. We hope that this report will contribute to efforts towards realising a circular economy in ASEAN.

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