



POLLUTANTS

Nitrogen and Phosphorus

A GETTING STARTED GUIDE

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ABOUT THIS SERIES

This guide is part of our series of Getting Started Guides that supports your company to develop an [embedded sustainability strategy](#). Each guide tackles a specific sustainability sub-issue and explores what your company needs to do to support the resilience of the environmental and social systems around you.

In each guide, we address relevant trends, system thresholds, key concepts, key actors, and key resources. We also offer guidance on how to address the impacts of decisions and activities in your operations and value chains as well as developing credible goals and outlining key corporate actions and internal targets that can help to provide clarity on the work ahead.

We recommend you read the first guide in the series, [Getting Started Guides: An Introduction](#), which explains our overall approach and the value of setting a clear strategy anchored in your company's most material issues. It also explains how you can leverage process-based interim targets to clearly outline and track the specific actions that your company needs to take to achieve its high-level goals.

A complete list of focus areas and sub-issues can be found in our guide [Scan: A Comprehensive List of Sustainability Issues for Companies](#).

This guidebook addresses **Nitrogen and Phosphorus**, part of the broader sustainability issue of **Pollutants**.

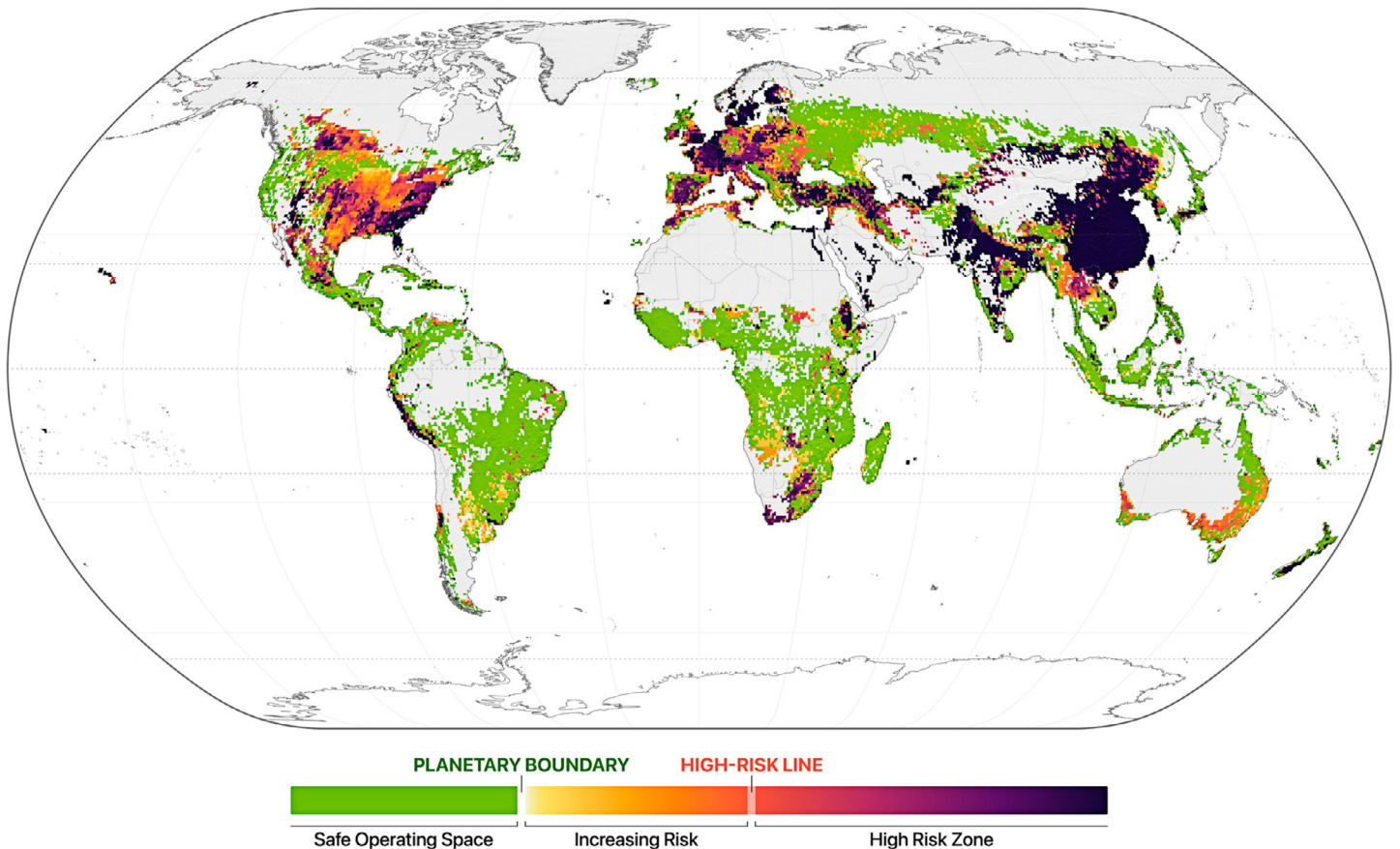
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SETTING THE STAGE – THE CHALLENGE OF NUTRIENT POLLUTION

Unmanaged and improperly managed pollutants are having a dire impact on human health, are major contributors to the global climate and nature loss crises, and exacerbate social inequities. These pollutants are contaminating the air, land, oceans, and freshwater bodies, with negative impacts for human and ecosystems health and overall resilience of communities and economies.

Nutrient elements are essential for supporting life and maintaining ecosystems, yet human-caused processes have disrupted natural cycles and altered the nutrient balance for living organisms.

The [Planetary Health Check](#), produced by the Stockholm Resilience Centre, notes that the modification of biogeochemical flows has crossed a “planetary boundary” – where human-made changes to the Earth have fundamentally disrupted the stable environment of the last 10,000 years – to the point that it is damaging the biological and physical processes that underpin all life. In particular, the industrial fixation of **nitrogen** – the artificial process of converting stable nitrogen from the atmosphere into bioreactive forms – and the flow of **phosphorus** into the world’s oceans have disrupted natural biogeochemical flows.



Source: [Planetary Health Check 2025](#)

Phosphorus and nitrogen are key ingredients in synthetic fertilisers.

Phosphate rock is the main source of easily accessible phosphorus. Whereas pure nitrogen must be chemically bonded or 'fixed' with other elements for it to be made useable or 'reactive,' either through natural or artificial processes.

Nitrogen is the most abundant element in Earth's atmosphere. Approximately 78% of the air we breathe is made up of nitrogen gas (N_2). However, this form of nitrogen cannot be used by most organisms. For much of human history, this process has been undertaken by soil bacteria (often in symbiotic relationships with plants and fungi) and lightning. The invention of industrial nitrogen fixation in the early 20th century made it possible to convert molecular nitrogen from the atmosphere into reactive forms of nitrogen (N), such as those used in synthetic fertilisers. Since that time, the use of synthetic fertilisers in agriculture has seen dramatic growth, [particularly since the 1960s](#).

Before the widespread use of synthetic fertilisers, the processes of nitrification and denitrification in nature were in harmony. Human activities, however, have disrupted this balance.

Nitrogen and phosphorus are key elements in the global biogeochemical cycle, essential nutrients in terrestrial and aquatic ecosystems, and vitally important to local and global economies and sustainable development agendas, yet in many parts of the world there is an excess of these nutrients in the environment because of industrial and agricultural activity. The amount of reactive nitrogen produced by humans is now far greater than the amount created through natural processes, and too much of this reactive nitrogen is now accumulating in the environment. Excessive and/or ill-timed application results in nutrient accumulation in surface and groundwater bodies, and once released to the environment, these nutrients are costly to control.

This excess is having a profound impact on nature and communities, including the destabilisation of key ecosystems and the services and livelihoods they support. Nutrient pollution is contaminating the water and air, degrading soils, causing toxic algal blooms, and creating hypoxic "dead zones" in the world's oceans through eutrophication.

UNDERSTANDING THE KEY SOURCES OF NITROGEN AND PHOSPHORUS POLLUTION

Nutrients enter and accumulate in the environment from a wide variety of natural sources, such as the decomposition of organic matter, the weathering of rocks, soil erosion and sediment transport, volcanic activity, and from biological nitrogen fixation (such as from certain bacteria and legumes). This allows for healthy and fertile ecosystems that can support an abundance of life. Unfortunately, although life depends on nutrients, too many nutrients have a negative effect.

Nutrient pollution occurs when too many nutrients – especially nitrogen and phosphorus – enter into ecosystems and disrupt the biogeochemical balance, primarily as the result of human activities. Key sources of anthropogenic nutrient pollution include runoff in urban areas where lawn and garden fertiliser is used; municipal wastewater and sewage; and fossil fuel combustion and industrial pollution. Wildfires and the burning of forests can also increase emissions of nitrogen oxide (NO), a harmful component of smog, nitric acid rain, and ground-level ozone, and nitrous oxide (N_2O), a potent greenhouse gas, known collectively as NOx.

Industrial agriculture is an especially large source of excess nitrogen and phosphorus, such as from the use of synthetic fertilisers and animal manure, waste from livestock and feedlots, and irrigation runoff.

Unfortunately, global nitrogen use is extremely inefficient. Only a fraction of the reactive nitrogen or the phosphorus in fertiliser is actually taken up by

crops, resulting in large quantities of both nutrients remaining in the environment and disrupting ecosystems. Studies indicate that between [50%](#) and [80%](#) of applied nitrogen in agricultural use is lost to the environment as pollution through various pathways, and that these losses are increasing as nitrogen fertiliser use increases. This equates to approximately [200 million tonnes of reactive nitrogen](#) being lost to the environment each year, leaching into water systems and emitted to the air, and amounting to an annual cost of approximately \$200 billion. Further, [nearly half of the 20 million tonnes of phosphorus](#) that are mined each year end up washing into the world's oceans – approximately eight times the natural rate of input.

Worse yet, the global use of synthetic nitrogen fertiliser has increased more than tenfold between 1961 and 2024, from approximately [11.5 million metric tonnes](#) to approximately [118 million metric tonnes](#), and phosphorus use more than quadrupled, from approximately [10.8 million metric tonnes](#) to approximately [47 million metric tonnes](#).

Although nitrogen and phosphorus use has largely stabilised in Europe and North America, these regions still carry the [legacy of decades of heavy fertiliser application](#), which continues to affect soils, groundwater, and coastal waters. Additionally, nutrient use is rising sharply in Asia due to population and economic growth.

UNDERSTANDING THE IMPACTS OF NITROGEN AND PHOSPHORUS POLLUTION

Nutrient pollution is one of the most pressing pollution issues facing humanity, threatening our environment, climate, communities, and economies. Nitrogen pollution in particular is the [greatest driver](#) of biodiversity loss after habitat destruction and greenhouse gas emissions, and is a key contributor to climate change.

[Nutrient pollution](#) is a process that occurs when too many nutrients, mainly nitrogen and phosphorus, are added to bodies of water. In freshwater lakes, reservoirs, streams, and in the headwaters

of estuarine systems, nitrogen is often naturally abundant, and phosphorous is the limiting nutrient for algal growth. For this reason, the introduction of [excess phosphorous is the most common cause of eutrophication in freshwater systems](#). Whereas, in the ocean, phosphorous is more naturally abundant and nitrogen is believed to be the key mineral nutrient controlling algal growth. Estuaries and continental shelf waters are a transition zone, in which excessive phosphorous and nitrogen can both create problems.

These excess nutrients can result in [eutrophication](#) – a process in which bodies of water are overly enriched by nutrients, causing rapid and excessive growth of phytoplankton, unicellular microalgae, macroalgae (such as seaweed), and other marine plants and organisms, often called a “bloom.”

This algal growth can block the light that is needed for plants, such as seagrasses, to grow, resulting in reduced species diversity; damage to coral reefs; and other acute and chronic impacts.

When algae and seagrass die, bacteria begin to decompose the organic matter. During this process, bacteria use large amounts of dissolved oxygen for cellular respiration, which can create a hypoxic (low oxygen) or even anoxic (no oxygen) “dead zones,” resulting in illness and death for fish, crabs, shellfish, and other marine organisms.

Further, some blooms consist of cyanobacteria that mimic algae in their appearance and ecological role. These harmful algal blooms (HAB) can release toxins into the water that can be dangerous to people and animals if they consume or come into contact with contaminated fish or shellfish from the water. People who drink or swim in water affected by a HAB can experience rashes, stomach and liver illnesses, respiratory problems, and neurological effects. Disinfectants used to treat pathogens in drinking water can also react with algal toxins to create chemical byproducts called dioxins, which are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones, and cause cancer.

Even when algal blooms are not toxic, they can still have [other negative impacts](#), such as reducing the ability of fish and other aquatic life to find food, harming or killing fish by clogging their gills, and causing entire populations to leave an area or die.

Eutrophication has emerged as one of the leading causes of water quality impairment over the past fifty years and is largely attributed to the rapid increase in nitrogen and phosphorus flows into the natural environment, caused by intensive agricultural practices, industrial activities, and population growth.

Many of the world's freshwater lakes, rivers, streams, and reservoirs suffer from eutrophication. [Over 500 coastal areas](#) globally are impacted, and the number of "dead zones" in the world's oceans have increased from 10 cases in 1960 to over 400 documented cases today. This threatens significant consequences for the millions of people who depend on them for sustenance; [more than 90%](#) of the world's fisheries depend on estuarine and near-shore habitats to some extent.

Nutrient pollution is also directly linked to both climate change and air quality. Reactive nitrogen contributes to the formation of particulate pollution, smog, acid rain, and potent greenhouse gases like nitrous oxide (N₂O) that contribute to global heating and harm the ozone layer. [Nitrous oxide is approximately 270 times more powerful](#) than carbon dioxide per tonne of emission at warming the Earth, and it is estimated to be [responsible for approximately 10% of net global warming](#) since the industrial revolution. Nitrous oxide emissions have risen by [30% in the past four decades](#), and with an atmospheric lifetime of up to 200 years, N₂O is now the dominant ozone-depleting substance emitted through human activities.

Excess nutrients can also have negative effects on biodiversity and the resilience of ecosystems on land. Excess nitrogen and phosphorus can cause nutrient saturation in forests, resulting in soils becoming acidic and losing their richness. [New research](#) also suggests that ecosystems such as

forests, heaths (a type of shrubland habitat), and surface waters are more sensitive to atmospheric nitrogen pollution than previously thought.

As for human health, the presence of nitrates and nitrites in drinking water is associated with a range of health concerns, including [thyroid dysfunction](#), [low blood pressure](#), and [adverse reproductive outcomes](#), such as congenital abnormalities, low birth weight, and birth defects. Current science also suggests an association between [cancer and exposure to nitrates](#) in drinking water when conditions result in nitrosation within the human body – a chemical process that occurs in the presence of nitrosating agents, such as nitrites or nitrates, and can result in the formation of carcinogenic nitrosamines. Meanwhile, as of 2022, the WHO estimates that [77%](#) of people breathe annual average concentrations of nitrogen dioxide (NO₂) that are beyond safe levels, which causes inflammation of the airways, reduced lung function, increased asthma attacks, and is associated with cardiopulmonary effects, affected pregnancy and birth outcomes, autoimmune disorders, cancers, and premature death.

One of the most concerning and well-documented effects of nutrient pollution in drinking water is methemoglobinemia, also known as "blue baby syndrome," which is caused by elevated methemoglobin in the blood. Methemoglobin is formed when the iron center in hemoglobin – a protein in red blood cells – is oxidised from ferrous iron to ferric iron. Hemoglobin, once transformed to methemoglobin, cannot oxygenate tissues adequately. The unique physiology of infants puts them at increased risk of developing methemoglobinemia, which can result in cyanosis, rapid heartbeat, shortness of breath, nausea, diarrhea, lethargy, loss of consciousness, seizures, and in serious cases, death.

It is estimated that nitrogen pollution costs the global economy [between US\\$340 billion and US\\$3.4 trillion annually](#) when accounting for its impact on human health and ecosystems.

ADDRESSING THE IMPACTS OF NITROGEN AND PHOSPHORUS POLLUTION

To address the impacts of nitrogen and phosphorus pollution, governments, industry leaders, and non-governmental organisations are collaborating and forming coalitions to drive action.

The [Colombo Declaration on Sustainable Nitrogen Management](#) was adopted in 2019, with the ambition of halving nitrogen waste by 2030. Spearheaded by Sri Lanka with support from the United Nations Environment Programme (UNEP), the declaration aims to improve how nitrogen is produced, used, and managed globally, with supporting countries agreeing to develop national nitrogen action plans, improve nitrogen-use efficiency in agriculture, reduce nitrogen pollution in air and water, promote recycling of nitrogen in food and waste systems, and more.

UNEP hosts the [Global Partnership on Nutrient Management](#), which was established at the United Nations Commission on Sustainable Development in 2009 to tackle the challenge of producing more food and energy with less environmental pollution. UNEP has also adopted resolutions calling for sustainable nitrogen management in [2019](#) and [2022](#), with the second resolution encouraging member states to "...accelerate actions to significantly reduce nitrogen waste globally by 2030 and beyond through the improvement of sustainable nitrogen management."

The [Kunming-Montreal Global Biodiversity Framework](#), adopted in 2022, calls for a reduction of pollution to levels that are not harmful to biodiversity by 2030. Specific to nutrient pollution, it calls for reducing excess nutrients lost to the environment by at least half, including through more efficient nutrient cycling and use.

The [Global Framework on Chemicals](#), adopted in 2023, set out a roadmap for protecting nature and communities from the harmful impacts of nutrient pollution, calling for the adoption, implementation,

and enforcement of legal frameworks to prevent or minimise adverse effects from chemicals and waste; calling on companies to implement measures to prevent or minimise adverse effects from chemicals throughout their life cycle; calling for governments to implement policies and programmes to increase support to safer and more sustainable agricultural practices; and calling for the development and implementation of sustainable chemical and waste management strategies for major economic and industry sectors that identify priority chemicals of concern, as well as standards and measures to reduce their impact and their input along the value chain – all by 2030.

THE RISK TO BUSINESS

These pollutants matter for business. Across a broad range of industries, businesses are facing credible and mounting risks from a decline in the societal acceptance of pollutants, an increase in abatement and pollution management costs, legislative and regulatory changes, and the growing risk of legal challenges and litigation from parties that have suffered harm, loss, or damage from pollution.

Nitrogen and phosphorus pollution damages agriculture, fisheries, and tourism, and communities dependent on freshwater or coastal resources face economic losses and health risks from contaminated water supplies.

Businesses have a crucial role to play in protecting people and nature by eliminating pollutants from their own operations and in their value chains. Companies need to understand how their operations and value chains may be directly or indirectly contributing to air, water, and soil pollution and the cascading effects these impacts may have on their business, society, and the environment. They need to review and rethink their processes to limit, and ideally eliminate, the release of excess nutrients from their operations, value chains, and/or products; invest in innovation; and work with policymakers and peers to advance the resilience of key systems.

Note. Sustainability issues are generally systemic issues, because they are deeply interconnected and rooted in complex environmental, social, and economic systems. In these guides, a system threshold is defined as the point at which the resilience of an environmental, social, or economic system becomes compromised. This occurs when the total impacts imposed on the system exceed its capacity to assimilate those impacts.

SYSTEM THRESHOLD

There is a limit to the concentration and volume of pollutants that the Earth and particular ecosystems and communities can withstand before their resilience and well-being are significantly – and perhaps irreversibly – eroded. Novel entities are one of the nine Planetary Boundaries that support and regulate Earth's systems. Research suggests that the boundary for what is considered a safe operating space for novel entities has already been breached.

In the pursuit of a corporate strategy that addresses the issue of nutrient pollution, it is important for your company to determine appropriate and defensible limits within which it must function. Identifying the limits above which excess nitrogen and phosphorus in air, water, and soil impact human health and nature – let alone threaten environmental, social, and/or economic collapse – is an urgent priority.

In order to safeguard human health against the harmful impacts of nitrates and nitrites in drinking water, with a specific emphasis on the maximum concentration level required to protect against methemoglobinemia and thyroid effects for the most vulnerable subpopulations, the World Health Organization (WHO) has specified a permissible limit of 50 mg/L for nitrate and 3 mg/L for nitrite. There are also varying local, regional, and national recommendations for nutrient criteria for protecting aquatic ecosystems (such as from algal growth), with context-specific reference levels for maximum total nitrogen and phosphorus in streams, rivers, lakes, reservoirs, and other bodies of water.

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KEY CONCEPTS

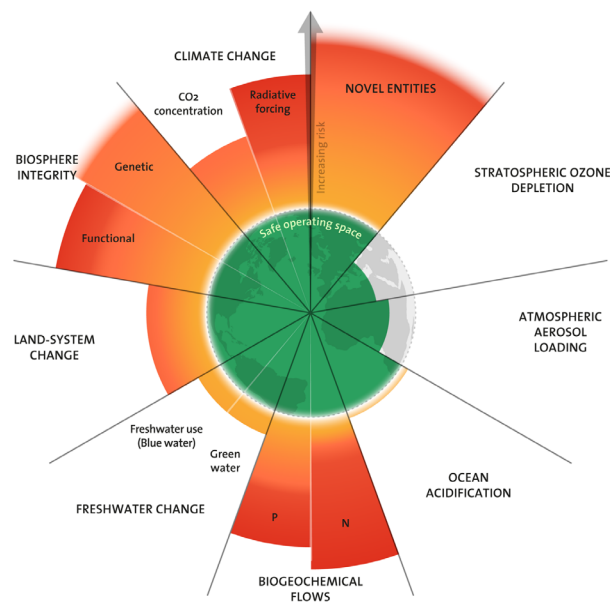
The **biogeochemical cycle**, or the **cycle of matter**, refers to the natural pathway by which essential elements are circulated in the environment between living organisms, the atmosphere, and the Earth's crust. In each cycle, elements and compounds are transformed and cycled by living organisms and through various geological forms and reservoirs, such as the atmosphere, soil, and oceans. In order for the living components of major ecosystems (such as lakes and forests) to survive, the chemical elements that make up living cells must be continuously recycled.

The biogeochemical cycle can therefore be thought of as the pathway by which chemical substances move back and forth between the biosphere (the living or "biotic" component of Earth's environment) and the atmosphere, lithosphere, and hydrosphere (the non-living physical and chemical or "abiotic" components of Earth's environment).

Important elements that cycle through ecosystems are carbon, nitrogen, phosphorus, oxygen, sulphur, hydrogen, and water, and all these substances are key **nutrients** – substances that promote growth, provide energy, and maintain life.

Particularly relevant to the topic of biogeochemical cycles and nutrient pollution are **nitrogen** and **phosphorus**. These reactive nonmetals are essential building blocks for amino acids, proteins, and DNA, and are used in every process of an organism's body, from building, maintaining, and repairing cells and tissues to creating new life through reproduction.

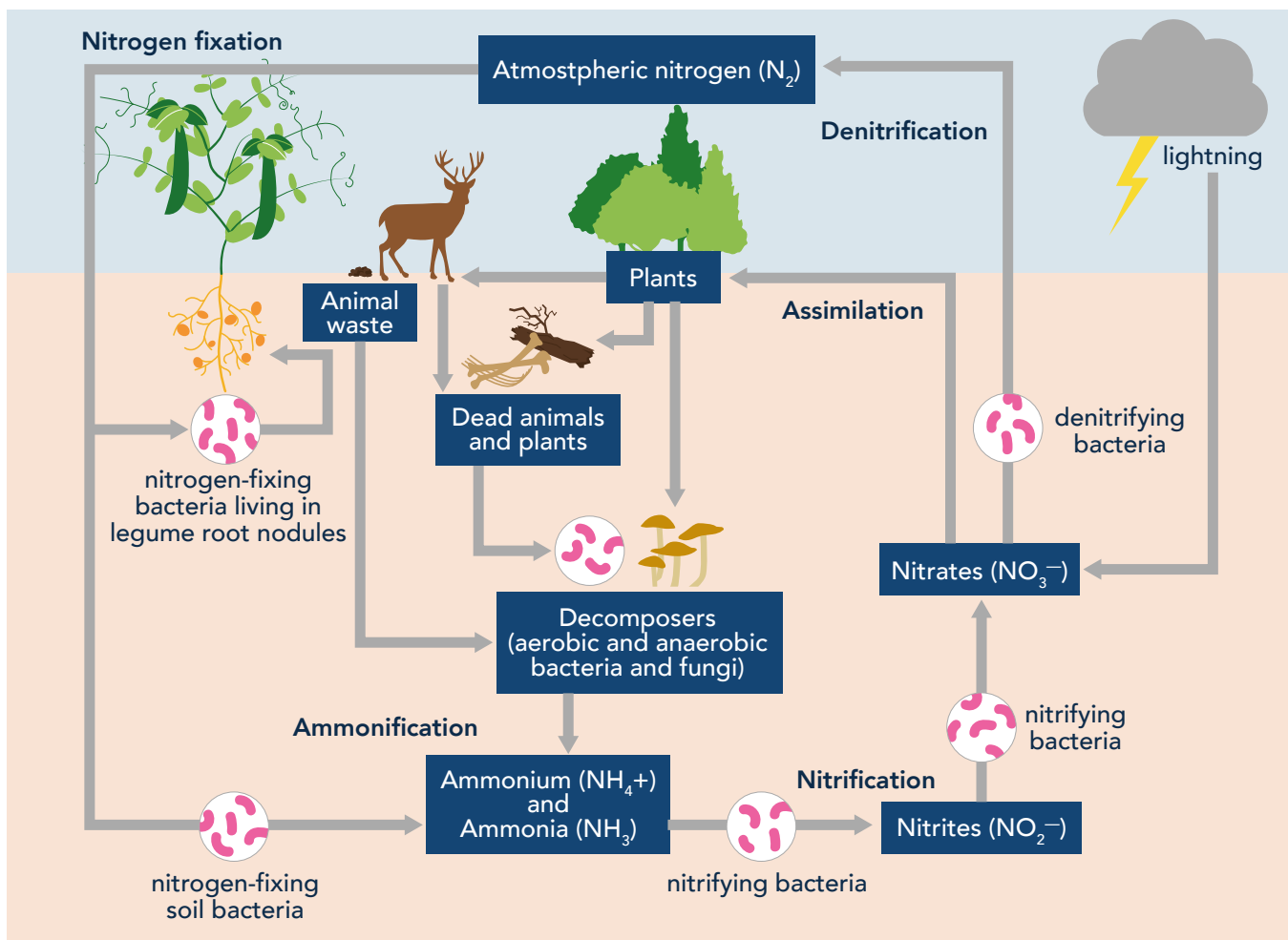
We have altered the world around us by modifying these biogeochemical flows, with impacts and long-term consequences that we do not fully understand. As shown in the diagram below, we have altered the flow of phosphorus and nitrogen and introduced more of it into the environment than can be safely incorporated.



Source: The Nine Planetary Boundaries, by [Stockholm Resilience Centre, 2025](#)

The **nitrogen cycle** is the biogeochemical cycle through which nitrogen is converted into multiple chemical forms as it circulates between atmospheric, terrestrial, and marine ecosystems. The majority of Earth's atmosphere is comprised of nitrogen gas (N_2), yet plants cannot use this nitrogen to make organic [compounds](#) for themselves and other organisms. It must first go through a process known as **nitrogen fixation**, which are chemical processes by which atmospheric nitrogen is converted into organic compounds that can be used by plants and other organisms. Although some nitrogen fixation occurs as a result of lightning breaking the strong bonds of nitrogen gas molecules to form nitric oxide (NO), most nitrogen fixation is carried out by nitrogen-fixing bacteria in the soil, which change nitrogen gas into

ammonia (NH_3) or ammonium (NH_4^+) molecules that plants can absorb through their roots. Nitrifying bacteria also change ammonium ions into nitrites and nitrates, which plants absorb more easily; this process of converting ammonium ions to nitrites or nitrates is called **nitrification**. Plants then absorb and use these various nitrogen-based compounds – a process known as **assimilation**. When plants and other organisms die, decomposers break down their remains and convert organic nitrogen back into ammonia, a process called **ammonification**. Other bacteria, called denitrifying bacteria, convert some of the nitrates in soil back into nitrogen gas in a process called **denitrification**. This process is the opposite of nitrogen fixation, and it returns nitrogen gas back to the atmosphere.

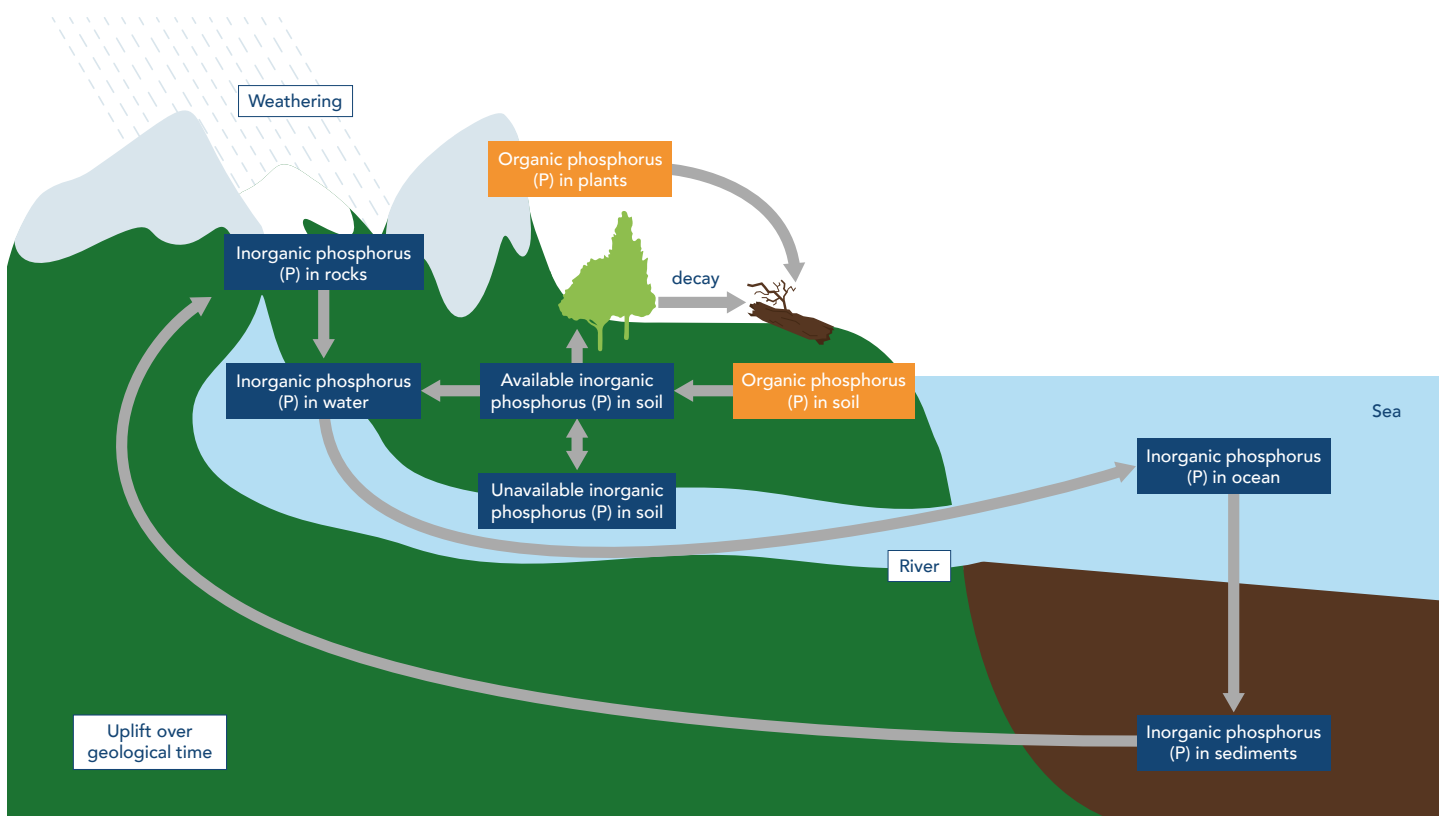


The Nitrogen Cycle. Source: Embedding Project

Through this cycle, nitrogen moves from the air into the soil, then into plants and animals, then *back* into the soil, and eventually returns to the air.

The marine nitrogen cycle is similar, albeit with different actors. Nitrogen enters the water through precipitation, runoff, or as nitrogen gas from the atmosphere and must undergo nitrogen fixation (performed primarily by cyanobacteria) before it can be utilised by phytoplankton. These accessible forms of fixed nitrogen (like nitrate and ammonium) move through the marine food web when zooplankton and other organisms consume phytoplankton. When these higher-order organisms die or release waste, decomposition returns nitrogen to the water through ammonification, and processes such as denitrification convert it back into nitrogen gas.

Compared to the nitrogen cycle, the **phosphorus cycle** is a slower and simpler process. The atmosphere does not act as a reservoir for phosphorus, as phosphorus and phosphorus-based compounds do not readily enter a gaseous state. Instead, deposits of phosphorus in the Earth's crust – primarily in sedimentary rocks – are released into surface waters via tectonic uplift, weathering, leaching, and surface runoff (and, increasingly, by mining), with some of these nutrients passing through freshwater and terrestrial ecosystems. Microorganisms produce acids that form soluble phosphate from insoluble phosphorus compounds, and this phosphate is used by algae and terrestrial plants that are consumed by animals. When these animals die and decompose, phosphorus is released back into the environment. Organisms that die in marine environments sink to the bottom, and the phosphorus released through decomposition can return to the surface by ascending currents, known as upwelling, and circulate in shallow sediments, or it can settle in the ocean depths to form new sedimentary layers.



The Phosphorus Cycle. Source: Embedding Project

Breaching the threshold of the planetary boundary for biogeochemical flows threatens the resilience of our global environment by destabilising the Earth's systems and causing irreversible damage. It also affects the status of other planetary boundaries; nutrient cycles are tightly connected to other boundaries, such as those related to climate change, biosphere integrity, and land-system change, which means that transgressing them drives a cascade effect across the Earth system.

The dynamic nature of our atmosphere, hydrosphere, and other geochemical cycles means that pollutants can travel far from their original source and can also disperse or concentrate in unpredictable ways – a phenomenon referred to as **transboundary transport**. Their impacts are also felt for a long time, as pollutants can persist for many years and accumulate in the environment. The effects of nitrogen and phosphorus pollution can accumulate far from their source through their transport in water and air currents that circle the globe. Excess nitrogen and phosphorus can travel thousands of miles from inland to coastal areas.

For instance, agricultural run-off, insufficient urban wastewater treatment, and industrial pollution all contribute to nutrient pollution in water. UNEP

reports that only [56% of all monitored water bodies worldwide are classified as having good ambient water quality](#). Nitrates and nitrites, for example, can accumulate in ground, surface, and coastal waters that communities use for drinking, bathing, growing and gathering food, and countless other everyday activities, and can expose people to a broad range of health risks.

Nitrogen can also travel in air currents. [Global air pollution is on the rise](#) due to rapid economic growth, population growth, and insufficient environmental management. [Nitrogen oxides](#) from combustion and [ammonia](#) from agriculture contribute to this issue. Additionally, as airborne pollutants return to the earth, through gravity or precipitation, they can find their way into water bodies.

Climatic changes exacerbate these issues. Historically, cold temperatures and a continuous snowpack froze nutrients like nitrogen and phosphorus in place until the watershed thawed in the spring, when plants could then absorb excess nutrients. However, global snowpack has become much less stable. With climatic shifts, increased rain-on-snow, snowmelt, and rainfall events are carrying nutrients and soil into streams and rivers during winter when dormant vegetation cannot absorb them. As a result, winter runoff impacts on nutrient pollution are increasing.

3

KEY PLAYERS

A wide range of organisations play a role in measuring and managing nutrient pollution.

The Global Partnership on Nutrient Management (GPNM) reflects a need for strategic, global advocacy to encourage governments and stakeholders to reduce nitrogen and phosphorus inputs to human activities, and provides a platform for establishing a common agenda and mainstreaming best practices and integrated assessments. To achieve this, the GPNM brings together diverse stakeholders – including government, research and academia, agricultural and fertiliser producers, regional and international intergovernmental organisations, NGOs, and UN agencies – and harmonises their efforts to deal with global nutrient challenges. This includes advancing improved understanding of the nutrient life cycle and its socio-economic and environmental impacts; sharing lessons learned to assist in analysis of policies, business models, and technological options for sustainable production and use of nutrients; facilitating the development of new approaches and projects to complement government efforts to reform or develop policy frameworks for sustainable nutrient management; and identifying key research and education needs for filling knowledge gaps.

The UN Environment Programme (UNEP) promotes global action on pollution and health. UNEP provides data on the status of pollutants globally, such as nitrogen dioxide and nitrogen oxides, as well as guidance on air quality standards, such as guidance on [Ambient Air Quality Legislation](#). On water, UNEP provides data-driven insights for informing water quality policies; partners with stakeholders for sustainable water management; and supports countries in monitoring, assessing, and improving water quality. In particular, the Global Freshwater Quality Database [GEMStat](#) provides credible and comprehensive data on freshwater quality to support scientific assessments and decision-making.

UNEP has also established working groups and global campaigns to reduce nutrient waste and improve nutrient use efficiency.

The World Health Organisation (WHO) provides guidance, monitoring, and reporting on global trends and changes in health outcomes associated with pollution (and related actions) at the national, regional, and global levels, as well as guidelines on water quality and human health that are used as the basis for regulation and setting global standards. This includes [guidelines](#) related to nitrate and nitrite contamination.

[The International Nitrogen Initiative \(INI\)](#) promotes policy-relevant research on nitrogen production, consumption, and losses to the environment, and the ensuing impact on ecosystems and human health; provides a forum for and catalyses interdisciplinary nitrogen research; supports multi-stakeholder engagement for the development of evidence-based policies for sustainable nitrogen management; and coordinates regional efforts to improve nitrogen management at all scales.

[UN-Water](#) is a coordination mechanism for the work of over 30 United Nations entities on water and sanitation issues around the world. It informs policy processes, addresses emerging issues, supports the monitoring and reporting on water issues (including wastewater treatment and sanitation for all), and builds knowledge for action.

[The Alliance for Water Stewardship \(AWS\)](#) is a global membership multi-stakeholder collaboration that contributes to the sustainability of water resources through the adoption of a universal framework for the sustainable use of water – the International Water Stewardship Standard. The framework helps water users to understand their impacts on water, including water quality impacts from pollutants, and offers guidance to achieve good water stewardship practices.

[The Science Based Targets Network \(SBTN\)](#) provides [Freshwater](#) and [Ocean](#) Hubs that offer guidance on corporate water stewardship and science-based targets for fresh and marine water. SBTN has also published detailed methodologies for companies to assess and prioritise impacts on freshwater quality and quantity.

Other key organisations include the **[Food and Agriculture Organisation](#)** of the United Nations (FAO), which provides data on fertiliser use, agricultural practices, and nutrient balances worldwide; the **[Organisation for Economic Co-operation and Development \(OECD\)](#)**, which tracks environmental indicators such as agricultural nutrient balances and provides policy recommendations; the **[World Resources Institute \(WRI\)](#)**, which develops relevant global datasets and tools, such as the [Water Risk Atlas](#), which provides modelling of eutrophication risks; and a broad range of national government agencies around the globe that measure nutrient levels in water and regulate pollution sources.

4

COMMITTING TO TAKE ACTION – MID- AND LONG-TERM GOALS

Committing to take action on Nitrogen and Phosphorus can include addressing many of the key topics listed above. The mid- and long-term commitments that your organisation elects to make should be based on your identified priorities, areas of greatest impact, and your capacity to undertake the work required. It is important to note that this section does not provide all possible mid- and long-

term goals related to this issue, but rather a sample of the goals that were most frequently adopted by companies in our research.

Common mid- and long-term goals and/or commitments on **Nitrogen and Phosphorus** include variations of the following:

Long-term goal: Zero impact on air and water quality from our operations by 20[XX]

- 100% of industrial emissions are safely abated or captured by 20[XX]
- Implement technology that can detect and remove nutrient pollution in wastewater to recommended safe limits, as per [key authorities]
- Support the responsible development of local wastewater collection and treatment systems
- Set science-based nutrient emission targets aligned with watershed limits
- Achieve net-positive water quality impact in priority watersheds

Long-term goal: Continuously reduce our impact on the environment along our entire value chain

- Require key suppliers to engage with vendors and implement appropriate nutrient use standards and practices
- Collaborate with local governments to restore eutrophic water bodies
- [X]% of synthetic chemical fertilisers will be phased out across our value chain by 20[XX]
- Support the transition to closed-loop water systems and the recovery and reuse of nutrients from wastewater
- Support phasing out the use of synthetic, chemical fertilisers and the adoption of organic fertilisers.
- Support regenerative ecological processes to manage soil fertility, such as through cover crops and crop rotation

*Are you setting new goals or interested in benchmarking your goals against leading practice? To help advance progress in credible corporate sustainability goals, the Embedding Project maintains a public goals database containing leading sustainability goals and commitments set by large companies globally. Explore our [Sustainability Goals Database](#) for more mid- and long-term goals on **Nitrogen and Phosphorus**.*

To further understand these issues, possible mid- and long-term goals and the process-based interim targets to get there, you may want to also consult [Pollutants in Air and Water: A Getting Started Guide](#). It is also worth noting that much of the work specifically related to water quality will occur concurrently within a broader water quality strategy – further guidance on key approaches to addressing pollutants in water can be found in [Water Quality: A Getting Started Guide](#).

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HOW TO GET THERE – PROCESS-BASED INTERIM TARGETS

Note: The following proposed timelines are only for guidance and are based on the pace outlined by other companies. The timeframe for actions and work for each step needs to be embedded in your organisational context, which may require different time allocations.

The sequence outlined below assumes that your company has significant impacts on **Nitrogen and Phosphorus** within its direct operations and that you will begin to engage with your value chain after learning and taking action to get your own house in order. Companies with greater impacts within their value chain may (and likely should) opt to engage with value chain partners at a much earlier stage.

YEAR 1: UNDERSTAND ISSUES RELATED TO NITROGEN AND PHOSPHORUS

Understand the safe thresholds (if any) for relevant pollutants that derive from your operations and your value chain and clarify the legal requirements for compliance in the regions where you operate. Ideally, much of this work will have already been completed as a part of your organisation's regulatory compliance processes.

If you operate in regions or areas where regulations are lacking, aim to understand what action would be necessary to preserve and enhance the health and wellness of key social and environmental systems.

Explore how your industry, your operations, and your value chain may impact air, water, and soil quality by contributing to nutrient loading. If you are unsure of where to begin, you may want to start by reviewing the key sources of nutrient loading, including agricultural runoff (fertilizers and manure), soil erosion, urban stormwater, sewage treatment plants, failing septic systems, and nitrogen oxides from vehicle exhaust and power plant emissions.

Consider prioritising nutrient pollutants that have been identified by key authorities as driving environmental issues in the areas where you operate, such as eutrophication events in coastal regions and bays. Further your understanding of

the different water, air, and soil quality factors, such as transboundary transport, contamination, and more as they become relevant to your operational context.

CASE STUDY: Companies across the agribusiness spectrum are disclosing the impacts that their activities may have on nutrient pollution. Yara, a Norwegian producer of fertilisers and other chemicals, [explains](#) that too much nitrogen and inappropriate nitrogen management can lead to nitrogen pollution in soils, rivers, lakes, coastal zones, and air, and that these losses can contaminate groundwater, alter soil chemistry, disrupt nutrient cycling, and drive shifts in plant communities and biodiversity loss by favouring some plant species over others, among other impacts.

YEAR 1: GATHER DATA AND ESTABLISH BASELINES

Review your current policies and processes regarding chemicals management and pollution control with an eye to how they apply to nutrients. Aim to understand your current systems, narrative, and the culture that exists around using and managing nutrients and chemicals that contribute to the release of nitrogen and phosphorus pollution to minimise the risk of harm to communities, and the environment.

To the extent that you can, determine relevant nutrient pollution levels using existing water, air, and soil quality data from public sources and by gathering data on water and air quality at your work sites, including effluents and potential point sources (such as stack emissions, wastewater discharge, or waste disposal) and non-point sources (such as nutrient runoff and seepage, including from the use and disposal of products by consumers).

Depending on the scope and scale of potential contaminants and their sources, your company may need to develop and implement a comprehensive process of continuous (and mobile) monitoring, using a combination of water and/or air quality sensors, real-time water and/or air pollution maps and exposure calculators, and data processing and modelling tools. You will also want to assess for potential gaps in monitoring.

For organisations whose products may release phosphorous or reactive nitrogen into the water or nitrogen oxides in the air in later parts of their lifecycle, it is crucial to understand and quantify the impacts of these products at the point that they may enter environmental systems.

Proper waste management may be outside of your company's direct control once these products are purchased by customers. It is therefore crucial that you identify, estimate, and document how these contaminants may impact the environment to better understand and focus your efforts where they are the most relevant. If this information is not readily available, it may be prudent to elevate relevant research as an urgent funding priority.

Examples of process-based targets for Year 1:

- By 20[XX], we will understand local and international regulations, standards, legislation, and associated commitments related to nutrient pollution in freshwater and marine environments.
- By 20[XX], we will understand potential water, air, and soil quality issues associated with our industry, our operations, and our value chain, including the primary source(s) of nitrogen and phosphorus pollution.
- By 20[XX], we will gather data on the state of water, air, and soil quality in the regions where we operate.
- By 20[XX], we will gather data to assess water, air, and soil quality impacts from our sites and operations.
- By 20[XX], we will map our wastewater streams and identify high-nutrient processes and the potential for runoff.

YEAR 2: UNDERSTAND POLLUTANT-RELATED RISKS

Nutrient pollution has significant implications for businesses. Public awareness of environmental issues and expectations for action are growing, and companies are under increasing scrutiny. Organisations face [stricter environmental laws and risk disclosure requirements](#), with non-compliance increasingly likely to result in legal action, fines, and damage to reputation. Your company needs to understand these pollution-related risks.

CASE STUDY: In a [landmark legal case](#), nearly 4,000 individuals in the UK (as well as businesses reliant on tourism and river activities) have filed a class action lawsuit against two chicken producers (Avara Foods Limited and Freemans of Newent Limited) and a sewage company (Welsh Water) for extensive and widespread pollution of the Rivers Wye, Lugg, and Usk. At the centre of the lawsuit is nutrient overload of nitrogen and

phosphorus in river waters, which has caused excessive growth of algae and led to significant losses in fish, plant, and invertebrate species. The case has become the largest environmental claim ever brought before UK courts, with claimants suing to secure compensation for losses caused by the pollution and policy changes to clean the rivers and prevent future harm.

YEAR 2: IDENTIFY BEST PRACTICE AND AREAS OF IMPROVEMENT

Identify industry or regional guidance on best practices to reduce impacts from excess nitrogen and phosphorus on water, air, and soil quality in your operations. While this will look different for each industry, region, and catchment context, it can include aspects such as implementing clean technologies that improve or redesign operational processes and waste and wastewater management, preventing run-off, and using the “4R” approach of using the right fertiliser type for soil and crop needs, at the right rate, at the right time, and in the right place.

Examples of process-based targets for Year 2:

- By 20[XX], we will conduct a baseline assessment of nitrogen and phosphorus discharge from our facilities.
- By 20[XX], we will implement routine water quality monitoring and screening.
- By 20[XX], we will establish a measurement process to better understand and track impacts on air and water quality from nutrient pollution deriving from our direct operations and quantify baselines.
- By 20[XX], we will understand air and water quality-related risks in our operations related to the use of nutrients.
- By 20[XX], we will identify relevant best practice for limiting and eliminating the release of nitrogen oxides from our facilities.

YEAR 3: SET TARGETS

Set site-based and/or catchment-specific targets that will align your organisation with protecting air, water, and soil quality to ensure resilience and wellbeing – these should aim to bring your activities in line with national or local thresholds and goals for the region or catchment. At a minimum, these targets should be informed by UNEP and WHO standards and align with relevant air and water quality guidelines.

While there may be several actors influencing air, water, and soil quality in the regions where you operate, leverage the social, economic, and technical information that you have to determine your ‘fair share’ of the effort. For example, WWF provides guidance on [setting science-based water targets](#), and the Science Based Targets Network’s (SBTN) [freshwater science-based targets](#) explore goal-setting for freshwater pollution.

YEAR 3: DEVELOP AN ACTION PLAN

Target your efforts to address nutrient pollution on sites, inputs, processes, and products where your research and risk analysis point to the greatest potential impacts on air, water, and soil quality. You may also want to prioritise improvements that are the easiest to implement to jumpstart the process. Train employees on risks associated with nitrogen and phosphorus pollution and methods to measure these contaminants and assess their impacts to air, water, soil quality, and ecosystem health. Engage employees in the planning process to support the uptake of your action plan at the site level. Establish processes and methodology to effectively track and analyse impacts on air, water, and soil quality to evaluate your progress.

CASE STUDY: Towards tackling deforestation and driving regenerative agriculture, Olam Food Ingredients (ofi) has set a goal to bring 2 million hectares under regenerative agricultural practices by 2030. To achieve this, ofi is employing a broad range of actions and initiatives, including recycling organic waste through bioreactors and converting it into bedding and organic fertiliser; helping farmers to reduce synthetic inputs by using organic alternatives like compost or manure, and by applying fertilisers more accurately; reducing emissions from crop residues (such as methane released by decomposing heaps) through improved cocoa pod residue management and the use of emission-reducing additives and inhibitors, such as natural feed supplements that cut methane from dairy; and using satellite intelligence, precision irrigation systems, and smart scheduling to optimise water efficiency, which also helps to improve soil health, enhance water retention, and reduce runoff and nutrient leaching.

Examples of process-based targets for Year 3:

- By 20[XX], we will determine progressive targets at appropriate levels (e.g. site-level or catchment-based) for water quality impact (such as [x] mg/L of reactive nitrogen [or phosphorus] discharged from operations).
- By 20[XX], we will ensure that 100% of site managers and supervisors are trained to understand the impacts of nutrient pollution on air and water quality and proper procedures for sustainable use of fertilisers.
- By 20[XX], we will install wastewater nutrient filtration systems at 100% of our priority facilities.
- By 20[XX], we will implement phosphorus recovery and reuse technologies and processes at 100% of our priority facilities.

YEAR 4: EXTEND YOUR LEARNINGS TO YOUR VALUE CHAIN

For many companies, the greatest source of nitrogen and phosphorus pollution resides within their value chain. Leverage your learnings from your efforts in your own operations to reduce nutrient-related impacts throughout your value chain. Share your air and water quality targets and insights with suppliers to encourage a greater understanding of impacts, the risks they pose to business, and the importance of action. Prioritise engagement with suppliers that have the greatest impacts and aim to co-develop solutions such as wastewater filtering and/or recycling of nutrients, or rethinking nutrient inputs (both in terms of input types and the timing of their application) to minimise adverse impacts on air and water quality.

YEAR 4: SUPPORT SYSTEM-WIDE CHANGES

Explore where your organisation has a broader role to play in raising awareness around nitrogen and phosphorus pollution and efforts to protect and improve air, water, and soil quality in the areas where you operate, and especially in areas where communities face structural barriers and inequity. Identify industry and/or local initiatives related to nutrient pollution where your organisation's participation and contributions may help to foster greater impact. Much of the work related to reducing and eliminating pollutants is underpinned by the availability of robust and accurate data; exploring whether and how your company can support improved data collection and monitoring can also be an important pathway towards broader industry and system-wide changes.

CASE STUDY: Dairy Industry Ireland (DII), which includes Kerry Group, Nestle, Carbery among its members, has partnered with Ireland's Local Authority Waters Programme (LAWPRO) and Teagasc, the Agriculture and Food Development Authority, to implement the new [Farming for Water European Innovation Partnership \(EIP\)](#). This project focuses on reducing phosphorus and nitrogen pollution (among other pollutants and waste) in rivers, lakes, wetlands, and all watercourses from agricultural lands, and aims to involve up to 15,000 farmers from across Ireland to take action where water quality is most at risk. To achieve this, Farming for Water promotes and supports the adoption of innovative best practice in nutrient management and the application of nature-based Natural Water Retention Measures (NWRM) and other suitable measures at the farm level, in accordance with principles of Integrated Catchment Management (ICM) and the best available science.

Examples of process-based targets for Year 4:

- By 20[XX], we will map nutrient pollution hotspots in our value chain.
- By 20[XX], we will require nutrient management plans from our agricultural suppliers.
- By 20[XX], we will work with our suppliers to support the uptake of science-informed practices that reduce nitrogen and phosphorus pollution in air, water, and soil across our value chain.
- By 20[XX], we will identify industry, local, and/or international collaboration opportunities to support systemic change towards reducing and eliminating pollutants in air and water.
- By 20[XX], we will organise technical sessions to promote education and information-sharing among stakeholders.
- By 20[XX], we will evaluate and act upon opportunities to support legislation that protects oceans, lakes, rivers, and other bodies of water from nutrient pollution.
- By 20[XX], we will develop (or adopt) and implement supplier-wide science-based fertiliser efficiency standards

GUIDANCE

UNDERSTANDING NITROGEN AND PHOSPHORUS POLLUTION

The new [Global Framework on Chemicals](#) provides a vision for a planet free of harm from chemicals and waste. Based around 28 targets, the framework outlines a roadmap for countries and stakeholders to collaboratively address the lifecycle of chemicals, including products and waste. It features a range of actions to ensure that a broad cross-section of stakeholders from governments, industry, international technical agencies, and civil society can support positive change on key topics, such as phasing out the most harmful chemicals, advancing circularity, and strengthening capacity-building, particularly in countries with insufficient enforcement regimes.

The [WHO Global Air Quality Guidelines](#) were created by the World Health Organisation for policy-makers, lawmakers, and technical experts, including industrial stakeholders and environmental impact assessment practitioners. This resource was created to offer quantitative, health-based recommendations for air quality, with the ultimate goal of providing guidance that can help to reduce the burden of pollutants on health worldwide. It provides specific recommendations on a range of air pollutants, including nitrogen dioxide. It also provides recommendations for implementation, monitoring, and evaluation of the guidelines.

TAKING ACTION ON NITROGEN AND PHOSPHORUS POLLUTION

The [Practical Guide to Chemical Management Due Diligence in Supply Chains](#) was created by the Responsible Business Alliance to provide you with a standardised, due diligence process template for managing chemical risks. It reflects RBA member companies' experiences and learnings and seeks to promote a collective understanding among businesses, governments, non-governmental organisations (NGOs), workers' organisations, employers' organisations, the public, and other stakeholders on best practices for responsible chemical management conduct to safeguard workers' health and the environment.

The [Alliance for Water Stewardship \(AWS\) Standard](#) can help you to understand your water impacts and to work collaboratively and transparently for sustainable water management within a catchment context. The standard has five steps: 1) gather and understand, 2) commit and plan, 3) implement, 4) evaluate, and 5) communicate and disclose. This Business guidance on the assessment of wastewater-related impacts from WBCSD can help your company to better understand and manage the impacts of untreated and partially treated wastewater. It provides a standardised, 5-step process for measuring, valuing, and managing the impacts of wastewater generated by your operating sites or those of suppliers.

This [Business guidance on the assessment of wastewater-related impacts](#) from WBCSD can help your company to better understand and manage the impacts of untreated and partially treated wastewater. It provides a standardised, 5-step process for measuring, valuing, and managing the impacts of wastewater generated by your operating sites or those of suppliers.

TOOLS

The [Global Environment Monitoring System for Freshwater \(GEMStat\)](#) provides water quality data from around the world on parameters such as pollutants, nutrient levels, and more.

The [Wastewater Impact Assessment Tool](#) from WBCSD aims to provide a site-level assessment of the pressures resulting from the industrial activities, allowing users to visualise the impacts of wastewater.

Explore more curated resources on [Nitrogen and Phosphorus](#) on our website.

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