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REDUCING NORWAY'S FOOTPRINT

BRINGING OUR PRODUCTION AND CONSUMPTION WITHIN PLANETARY BOUNDARIES

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WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

Alauda Consulting provides specialist consultancy services to support organizations create a better future for people and the planet. We do this through providing research and strategic insight into key sustainability issues associated with supply chains: deforestation and ecosystem conversion, biodiversity, policy, and poverty.

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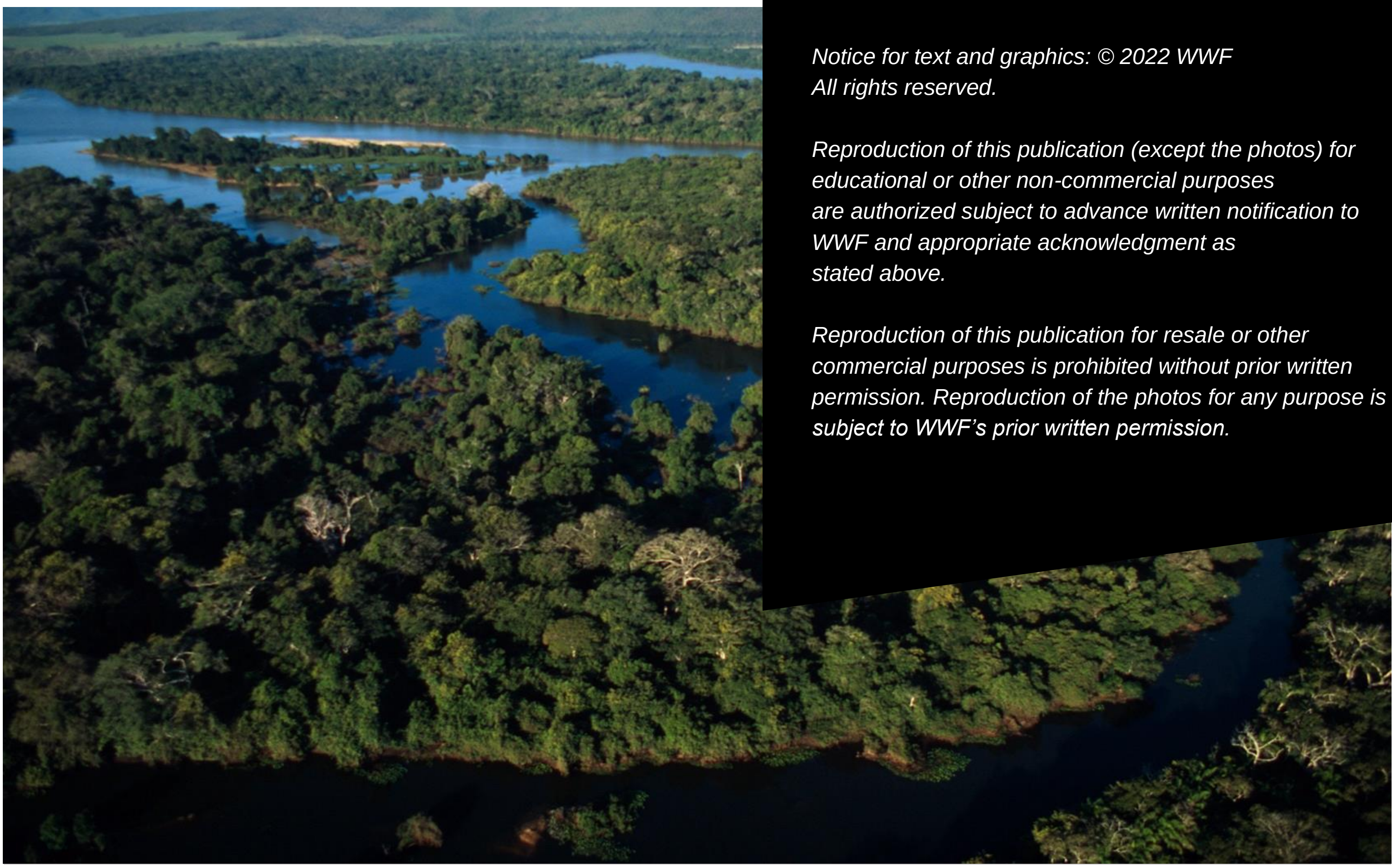

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“This is a serious report.
It documents how Norwegian production and consumption is breaking planetary boundaries, and thus contributing to the accelerating global nature and climate crisis.
We need to shrink our footprint to fit within nature’s boundaries.
Current policies are nowhere near the solutions we need for changing our production and consumption.
As this report shows, politicians and businesses must set new targets and put new measures and mechanisms to work. And they have to do it fast.”

Karoline Andaur, CEO, WWF-Norway

FOREWORD

Global biodiversity is in rapid decline. Our unsustainable production and consumption is currently breaking our planetary boundaries – leading us into an unprecedented nature and climate crisis. Norway's footprint on nature, meaning how much area and resources such as wood, food, metals, sand and rocks we use, is way beyond what the planet can tolerate. To limit global warming and reverse the rapid loss of biodiversity, we need to halve the footprint of production and consumption globally. For the first time, this report shows that Norway must reduce its footprint by two thirds in order to make its contribution towards the global goal of halving our footprint. This requires that decision-makers at all levels start to integrate the goal of reducing our footprint in all their decisions.

This is not an easy task, but the report outlines three areas of actions. First, we need to adopt a national target of halving the global footprint and use footprint indicators to systematically measure progress in our economy and governance. Second, all our production must become circular and reduce its dependency on new natural resources. Third, we must redesign our food systems and reduce consumption of food that puts high pressure on nature.

Reducing our footprint and becoming more circular must become a top priority for all, not only policymakers, but also the business and the finance sector. We need to act now in order to succeed in bending the curve of nature loss while ensuring wellbeing and welfare for all within planetary boundaries.

Karoline Andaur

Karoline Andaur,
CEO, WWF Norway

WHY WE MUST REDUCE OUR FOOTPRINT TO SAVE NATURE

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PLANET AT RISK FROM EVER-GROWING PRODUCTION AND CONSUMPTION

NATURE IN CRISIS

Human activities have significantly altered or destroyed about 75% of all our planet's ecosystems, causing biodiversity loss at a rate never seen before. The latest Living Planet Index (WWF, 2022) shows a devastating 69% decrease in wildlife populations since 1970[1], and that one million species are threatened with extinction globally. As a result of human activities, species are dying out at a rate 100 to 1,000 times higher than historical averages[2]. We are not only losing species, but also the ecosystems' ability to support life. Land degradation is already impacting the well-being of 3.2 billion people worldwide, and costs at least 10% of annual global GDP[3]. With more than half of the global economy depending on nature[4], the degradation of our natural world is putting countries, businesses, and the financial system at risk.

Loss of biodiversity and climate change are two interlinked problems that reinforce each other, and we are only now finally starting to fully understand how they interact and impact natural systems and processes that all life on Earth depends on.

WE ARE OVERSHOOTING OUR PLANETARY BOUNDARIES

Our planet has physical limits for how much pressure it can sustain. These limits are described by the so-called "planetary boundaries" framework, presented as nine processes that are fundamental for regulating the stability and resilience of natural systems[5]. Research indicates that six of the boundaries - biodiversity loss, land use, climate change, nitrogen and phosphorous cycles, green water (freshwater), and novel entities (i.e., chemical compounds created by human activities that are not found in nature) – have already surpassed safe levels[6].

The planetary boundaries define the "*safe operating space for humanity*" as the space in which humans can live and operate safely without the risk of generating abrupt, large-scale environmental changes. This is conceptualized by the green Earth at the center in Figure 1. When the safe boundaries are crossed (the dotted line in the figure), we enter a space where the risk of dramatic change increase due to destabilized system processes, and we increase the risk of generating large-scale abrupt or irreversible environmental changes. The time we have to react and prepare for changes gets shorter the further out from the safe space in the center we operate[7].

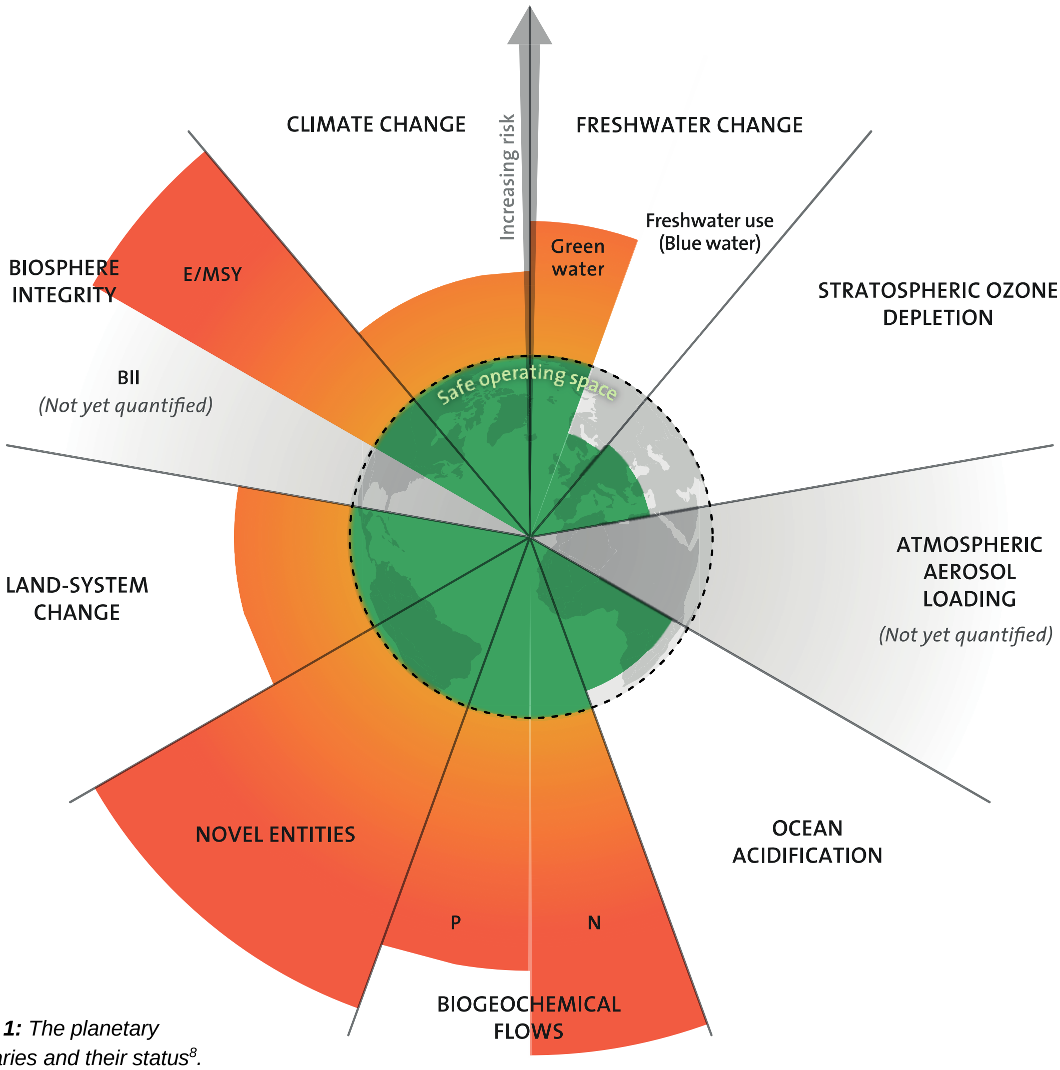

Figure 1: *The planetary boundaries and their status[8].*

THE IMPERATIVE OF HALVING THE FOOTPRINT FROM PRODUCTION AND CONSUMPTION

In order to reverse nature and biodiversity loss and achieve a world within planetary boundaries, we need to both protect existing, relatively unharmed nature, and restore a significant area of our planet's lands and oceans that have already been degraded as a result of human activities.[9]

But protection and restoration alone will not be sufficient, as seen in Figure 2. To succeed in ending the nature crisis, it is crucial that we tackle the underlying cause of both nature loss and climate change, that is our unsustainable production and consumption. In fact, research from the International Resource Panel has identified that the extraction and processing of natural resources, with biomass in the lead, to serve the demands of our economy, is the leading driver of about 90% of biodiversity loss and over 50% of greenhouse gas emissions[i]. The problem is not only how much we produce and consume, but also what, how, and where.

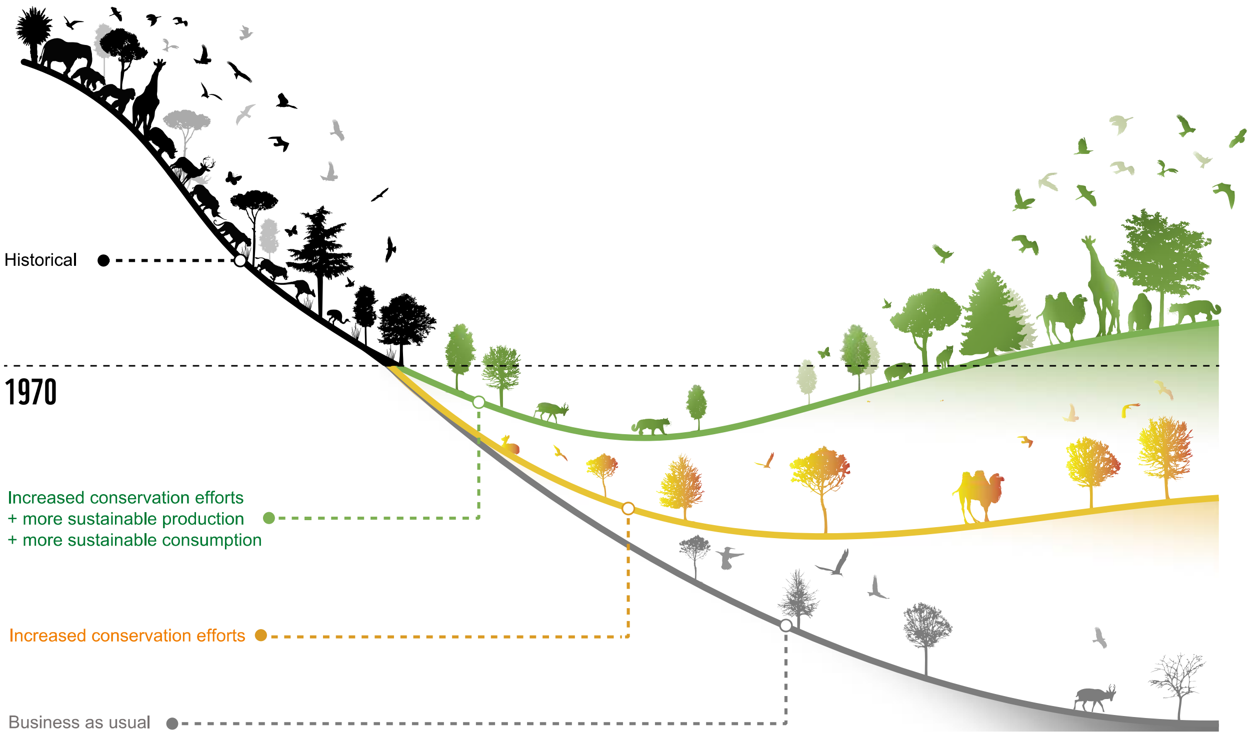

***Figure 2 – Reversing nature loss requires significant efforts to address unsustainable production:** Artwork illustrating historical biodiversity loss curve before 2010 (black) and different loss curves with different actions to address the loss. The green curve shows that efforts to improve the sustainability of production and consumption achieves a faster and steeper increase in biodiversity than conservation efforts alone (orange curve) and significantly more than business as usual. The artwork illustrates the main findings of a Nature article by Leclere et al 2020[10], but does not intend to accurately represent its results. Credit: Adam Islaam, International Institute for Applied Systems Analysis (IIASA).*

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[i] *"Resource extraction and processing make up about half of the total global greenhouse gas emissions and more than 90 per cent of land- and water-related impacts (biodiversity loss and water stress). Agriculture is the main driver of global biodiversity loss and water stress."* The remaining 10% and 50% of impacts is associated with activities from households and the rest of the economy. Source: IRP (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

Despite all the talk about sustainability, new technologies and how they increase efficiency by using fewer resources, data shows that there has been no decoupling of economic growth and resource consumption[11]. On the contrary, the global economy is now using even more resources to produce the same amount of economic growth.

In order to reduce pressure on nature, we need to profoundly change our economy and make it operate within the planetary boundaries. To do this, WWF has estimated that we need to halve the global footprint of production and consumption. This will massively reduce the pressure on biodiversity and other planetary systems that we rely upon for our existence. For this reason, "*halving the footprint*" has become one of the main targets under consideration for the UN Convention on Biological Diversity in December 2022. The Nordic countries has pledged that they will work to include a connected target, specifically on reducing "our global ecological footprint to a level well within planetary boundaries".[12]

Halving the footprint of production and consumption is a clear and straightforward target, but that doesn't necessarily mean it's easy to understand the underlying science behind it. Which includes how our footprint is connected to the planetary boundaries, what it consists of, and how best to measure and find good, targeted solutions for how countries and businesses can reduce their footprint.

WWF, together with Metabolic, has therefore developed a framework for understanding and unpacking what our footprint on the planet looks like, and how production and consumption relates to the planetary boundaries.

This report explains the footprint framework in more detail and examines how it can be applied to Norway to better understand the Norwegian footprint from production and consumption. We also define which reduction targets Norway needs to set to reflect our responsibility and fair share of the target of halving the global footprint from production and consumption.

Through this report, we seek to give a better understanding of six different footprint indicators: ecological, material, biomass, phosphorus, nitrogen, and greenhouse gas. To get a complete understanding of our nature footprint, we also look at five other drivers and consequences of our production and consumption: chemical pollution, water pollution, air pollution, water availability and flows, and land-use change and degradation.

Finally, we present what policymakers, businesses and the finance sector must do to reverse the loss of nature and reduce our footprint. Solutions are built around three systemic transformations that are pivotal for halving the global footprint and reducing the pressure our production and consumption puts on the nine planetary boundaries: putting nature at the center of the economy; a circular revolution; and a food system transformation. We also include a discussion on how businesses and the finance sector can understand, measure, and reduce their own footprint.

METHODOLOGY AND APPROACH

DEFINING THE "FOOTPRINT"

What we commonly refer to as "footprint" refers to the collective impact of extraction, production, consumption, and related socioeconomic activities on nature and the functioning of natural systems, as well as the drivers and pressures that cause this impact. Many different models and indicators have been developed that attempts to define and quantify the footprint and sustainable limits of human activities. A commonly known measure is the ecological footprint, a complex metric that provides a good overarching picture of our pressure on natural systems.

However, no single footprint model captures all activities or the total impacts and pressures of our production and consumption on nature. To provide more depth and clarity, additional footprint indicators that measure the specific flow of certain natural resources are needed. This report, therefore, relies on a framework developed by Metabolic and WWF for halving the footprint from production and consumption in a national context[13], initially developed for WWFUK[14] and further adjusted for this report.

This report looks in depth at six different footprints: ecological, material, biomass, phosphorous, nitrogen and greenhouse gas.


Sarah Pietrkiewicz

DESCRIPTION

Ecological footprint: The closest to a unifying measure that we can get. It measures the total demand for goods and services produced from nature relative to the productive *biocapacity* of various natural systems; land use, carbon emissions, timber, fish, and materials.

Material footprint: Measures four key resources used: fossil fuels; metals; non-metallic minerals; biomass. In this analysis, biomass is not included in the material footprint but analyzed separately.

Biomass footprint: Measures the consumption of plants and animal foods, forestry products and fishery products.

Phosphorous and **Nitrogen** footprints: Measure the production and use of these two key nutrients used as fertilizers in agriculture.

Greenhouse gas footprint: Measures the emissions of CO_2 and other greenhouse gases.

It is important to underline that the scope of the footprint encompasses both production and consumption and covers as such both domestic and overseas impacts. It includes the impacts of resources and goods imported, and the ones extracted or produced in Norway, that are consumed in Norway. Exports are not included. These resources or goods are consumed by other countries, and therefore part of their footprint. Because of this, the footprints presented here do not measure all of the pressure our economic activity puts on nature in Norway, as the nature impact from large exporting sectors such as aquaculture or petroleum sectors is not covered.

In our analysis we have also included a description of other drivers and consequences that also contribute to the overall nature loss and pressure on planetary boundaries; chemical pollution, water pollution, air pollution, water availability and flows, and land-use change and degradation, but whom we have not been able to give an estimate of a safe planetary limit due to the highly different impacts of the components of these footprints (e.g. emissions of chemical pollutants are quantified individually, and because they have different ecological impacts a single 'planetary limit' is not possible to estimate). These not-quantified footprints are highly linked to the other six footprints. For example, the consumption of biomass causes pollution, directly affecting water availability and flows, and is the main cause of land-use change and degradation.

A full description of the whole web of interaction between footprints and drivers are outside the scope of this report.

DEFINING A SAFE, AND FAIR, LIMIT

Globally, science shows that we need to halve the footprint. Our framework operationalizes this target for six different footprints at a national level, defining for each of them Norway's fair share of a global safe limit. We here rely on scientific studies that indicate the overall correlation between the individual footprint and the planetary boundary. Where no direct planetary boundary is set, a qualitative change to Norway's footprint is suggested, based on the available scientific (and where possible social and economic) impacts of the footprint. Through this, we achieve a clear scientifically based target for how much we need to reduce the respective footprint from our production and consumption to operate within a safe limit.

Inequality in income and distribution cause a great variation of the footprint amongst countries; simply put, richer nations have greater footprints than less economically developed countries[15]. The impact of consumption and production needs not only to be brought within sustainable levels, but there also needs to be a convergence of impact across and within regions and income groups. In other words, we need country-specific targets based on a country's relative contribution to the global footprint to secure a fair and equitable distribution of the responsibility in reaching the global goal of halving our production and consumption footprint. This will result in higher reduction targets than a halving for some countries, especially richer countries, and lower targets for other countries with a smaller footprint, giving room for growth, sustainable development, and eradication of poverty, particularly in developing countries[16].

Per capita footprints provide a fair way of assessing the extent to which a country must decrease its footprint. We therefore apply a per capita approach, where both the footprint and the corresponding safe boundary are set at the level of per capita resource consumption.

The result is six quantified reduction targets for Norway, for each individual footprint. Together, these represent the reduction needed to reach a per capita safe operation limit of production and consumption for Norway. It is important to note that while this helps us converge closer to the current global distribution of responsibility, it does not in itself reflect the whole, historical dimension of inequality, which lies outside the scope of this study.

A more thorough description of the different footprint calculations, their corresponding safe limits and Norway's reduction target for each, is found in the footprint deep dives.

DATA AND MODEL INPUT

We have used the same method for estimating the planetary limit per capita per footprint as WWF & Metabolic's original study for halving the global footprint.

The data used to estimate Norway's fair share of the global per capita footprint and Norway's actual footprint uses the most recently available estimate within the scientific and technical literature. However, this means there is variation in the date for which the footprint is calculated: from 2015 in the case of nitrogen and phosphorous, to 2020 for material footprint and biomass. This means that the older data may marginally over- or under-estimate Norway's current footprint, but is more transparent than the alternative approach, which would be to create modelled estimates of the existing footprints. It also highlights that many aspects of our impact on the natural world are not formally reported on, and hence do not feature in official government statistics. This is a significant shortfall in environmental reporting.

Where applicable, we include supportive data in the footprint deep dives. The global per capita footprint is used in the footprint deep dives to compare Norway's per capita footprint to the global average footprint per capita.

***Table 1** – Sources of data for comparing Norway's footprint with planetary limits*

Footprint	Norway per capita footprint	Global per capita footprint	Planetary limit per capita
Ecological footprint	Global Footprint Network[17]	Global Footprint Network[18]	WWF & Metabolic (2020)[19]
Material footprint	Material flow account, SSB[20] / Norway population	UN SDG Indicators[ii]	O'Neill et al. (2018)[21] adjusted for population with biomass excluded
Biomass footprint	Material flow account, SSB, SSB[22] / Norway population	UN SDG Indicators[23]	O'Neill et al. (2018)[24] adjusted for population with non-biomass excluded
Phosphorous footprint	O'Neill et al. (2018)[25]	Steffen et al 2015[26] / global population	Steffen et al 2015[27] / global population
Nitrogen footprint	O'Neill et al, 2018[28]	Steffen et al 2015[29] / global population	Steffen et al 2015[30] / global population
Greenhouse gas footprint	Consumption based climate account, Steen-Olsen et. al (2021)[31]	O'Neill et al, 2018[32]	Institute for Global Environmental Strategies, Aalto University, and D-mat ltd. (2019))[33]

[ii] UN SDG Indicators https://unstats.un.org/sdgs/report/2019/goal-12/ Non-biomass assumed to be 80% of global overall material footprint (18.7 billion tonnes in 2020, following Fridolin Krausmann, Karl-Heinz Erb, Simone Gingrich, Christian Lauk, Helmut Haberl, (2008). Global patterns of socioeconomic biomass flows in the year 2000: A comprehensive assessment of supply, consumption and constraints, Ecological Economics, Volume 65, Issue 3, pp 471-487, ISSN 0921-8009, https://doi.org/10.1016/j.ecolecon.2007.07.012.)

DEEP DIVE INTO NORWAY'S FOOTPRINT

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The following figure summaries the difference between Norway's per capita footprint and the planetary limit for the six footprints included in the analysis: ecological, material, biomass, phosphorus, nitrogen, and greenhouse gas.

We find that for Norway to contribute its fair share to a global target of halving the footprint of production and consumption, we would need to set a target of reducing our total national footprint by at least two-thirds.

This is based on the results that Norway is significantly exceeding the per capita planetary limit on all six footprints, and that reductions ranging from 30% (Nitrogen footprint) to 90% (Phosphorus footprint) are required to bring Norway's footprint back within planetary limits.

While an overall goal gives a direction, it is not adequate in itself, as one cannot achieve success by simply substituting achievement in one footprint with failure to reduce another. Therefore, we must dive deeper into the individual footprints to understand how we can align them with their respective planetary boundary.

The following sections provide more detailed information and a breakdown of each quantified footprint – ecological, material, biomass, nitrogen, phosphorus, and greenhouse gas.
This unpacks what the overall Norwegian footprint is composed of and respective reduction targets to reflect Norway's fair share of the global goal of halving the footprint of production and consumption, with examples of how it can be reduced.

Further follows a description of other indicators representing our footprint, which pressure the planetary boundaries and cause nature loss, but where the footprints have not been quantified. The included elements are chemical pollution, water pollution, air pollution, water availability and flow, and land-use change and degradation.

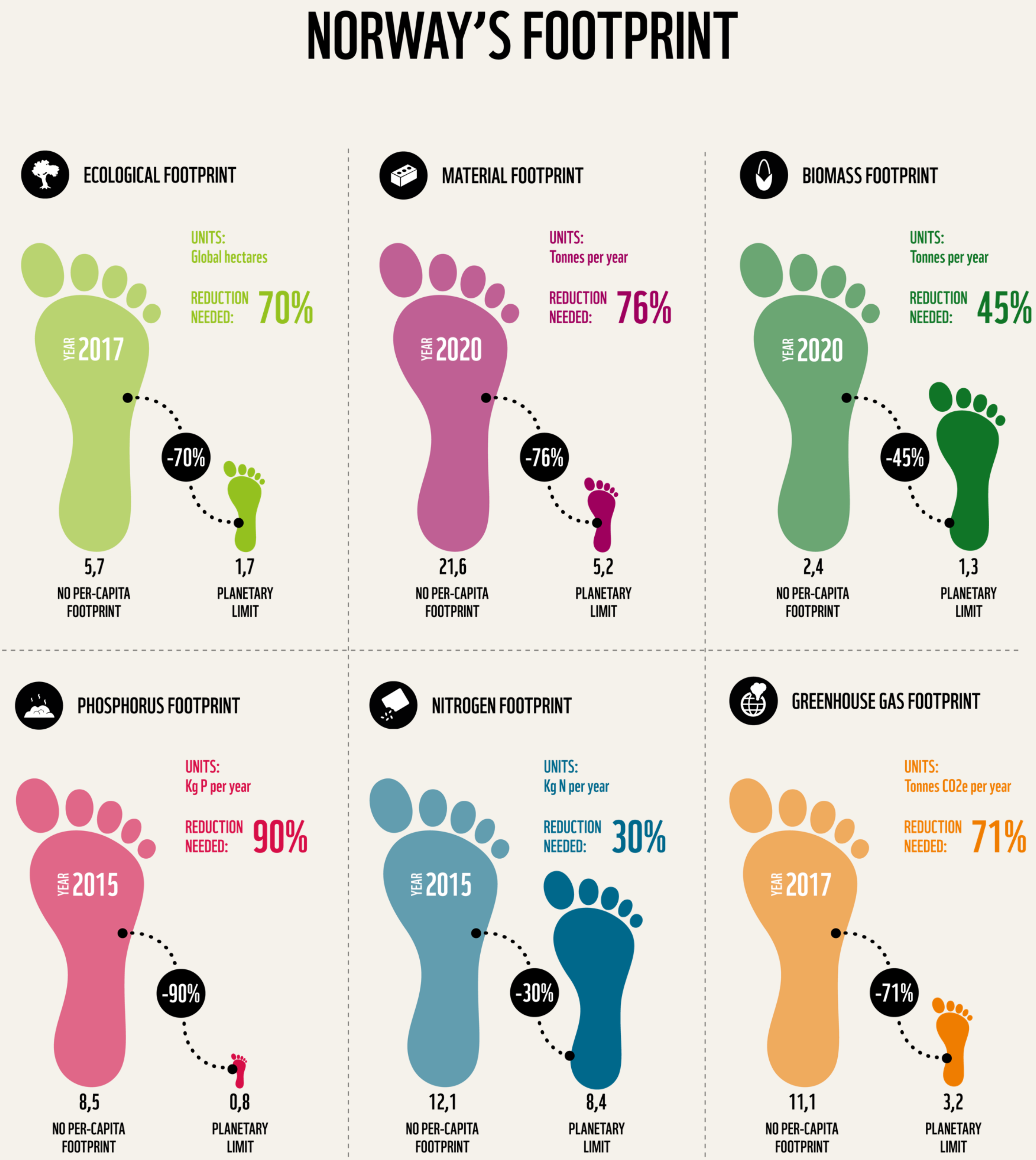


***Figure 3** – Norway's footprint, and needed reduction in footprints to stay within planetary limits by 2030*

ECOLOGICAL FOOTPRINT

Target: reduce Norway's ecological footprint by 70% by 2030

The ecological footprint is the most complex of the footprint indicators as it aims at providing the broadest view of our footprint. It measures our relationship with all of nature, ranging from photosynthesis to the carbon cycle, and it's the only metric that seeks to provide a truly global perspective on human demands against the planet's regenerative capability.

The ecological footprint measures how much nature we have available (supply) and how much nature we need to provide the goods and services that we (and thus our economy) demand, and how much nature that is required to absorb the waste and emissions we produce. The supply side is measured by the so-called biocapacity of different ecological systems such as forests, agricultural areas used for crops and grazing, fishing grounds and water. Biocapacity is measured in annual yields, i.e., the systems' ability to provide a particular resource within a safe limit; how much fish can be harvested without permanently damaging the stock? How much woodland can be cleared versus how much is regrown? Or the natural uptake of CO_2 of the same woodland versus annual industrial emissions[34]. The burning of fossil fuels are included in the same manner, measuring emissions relative to the absorptive ability of nature and the atmosphere to withstand these emissions. In order to live within the means of our planet, human's ecological footprint will have to be lower than our planet's biocapacity.

Both the ecological footprint and biocapacity are measured with one standard indicator, *global hectare (gha)*, which allows us to measure the balance of different ecological systems in the same quantitative way, e.g., measuring the overshoot of emissions on equal terms as that of forests, fish or land-use. By aggregating the results for each system, we get the total ecological footprint. This total "net" overshoot estimate describes the total pressure we as a civilization put on nature.

DEFINING A SAFE LIMIT

The ecological footprint is itself not a planetary boundary but a compound indicator measuring the relative state of several natural systems. Therefore, the notion of a "safe operating space" is not attributable to any one factor, but rather measured as the average level of biocapacity available for human consumption across the various systems. When demand surpasses biocapacity, these ecological systems and their ability to support human life and regain balance, deteriorate. This means that a deficit occurs in the short term, and we are overusing nature at the expense of its long-term viability.

For 2021 the safe planetary limit was set at 1.6 gha. The average global ecological footprint is measured at over 2.8 gha. While this may sound complicated, the Earth Overshoot metaphor tells us a simple and powerful message: we currently use 1.75 times the capacity of our planet's nature, massively overshooting our "planetary" budget. This relationship is often conceptualized as the Earth Overshoot, a visual representation showing how our consumption and pressure on the natural system surpasses the Earth's capacity in number of planets.

NORWAY'S ECOLOGICAL FOOTPRINT

For comparison, Norway has a per capita ecological footprint of 5.7 gha per year. This means that if everybody lived like Norwegians, we would need 3.6 planets, more than three times the safe operating space and nearly twice as much as the average per capita footprint, to support our way of living. It is important to note that this figure includes imported goods, whose biocapacity demand is estimated based on trade statistics but excludes the footprint of exported goods.

A breakdown of Norway's ecological footprint shows that the most significant contributor to the footprint is CO_2 emissions, which have grown to overtake fishing as a primary driver to overshoot. Consumption of forest products constitutes the third largest overshoot but has remained somewhat consistent over time. However, cropland consumption has more than doubled since 1961, as Norway increasingly imports more foodstuff and animal feed from other countries. The two remaining categories are grazing lands and built environments. Both have not increased significantly over time in the ecological footprint statistic. It is important to note that this does not imply that land use from agriculture or building and infrastructure does not negatively impact nature. This is not captured in the scale of the ecological footprint indicator: issues related to cropland are more accurately addressed under the land-use-footprint, or biomass-footprint, which go further into understanding cropland and land-management and their negative environmental impacts.

HOW CAN WE REDUCE THE ECOLOGICAL FOOTPRINT BY 70%?

The ecological footprint paints a picture of the Norwegian economy's consumption of the planet's shared biocapacity. By breaking down the overall ecological footprint into its different components and tracking them over time, we get a birds-eye view of how our consumption contributes to nature degradation and how this changes over time.

However, the ecological footprint is not necessarily enough to trigger an appropriate governance response. Since all ecosystems are measured with the same unit, global hectares, this does not imply interchangeability. For example, one could suggest that CO_2 emissions are the real problem, as they constitute roughly half of the ecological footprint, and that if we remove them, everything should be ok. However, this is not the case, as the different ecosystems are not interchangeable and operate with their unique characteristics and natural limits. To assume that, for example overfishing could be solved by reducing CO_2 emissions alone would of course be false.

In this respect, talking about an overall reduction based on a common average is therefore misleading. It is more accurate to say that the level of reduction should be reached within each of the included systems. The ecological footprint can be used to set an overall direction and narrative. But in order to succeed in halving the footprint, it is necessary to look closely into several footprint modules to better understand Norway's footprint of production and consumption, and how to take targeted action to reduce it.

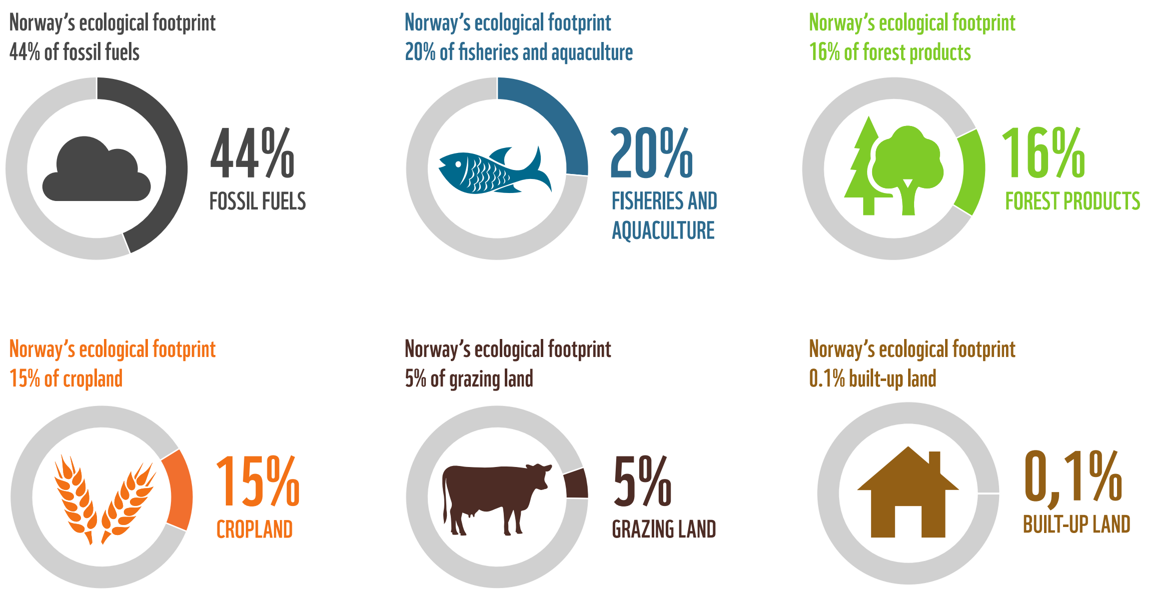
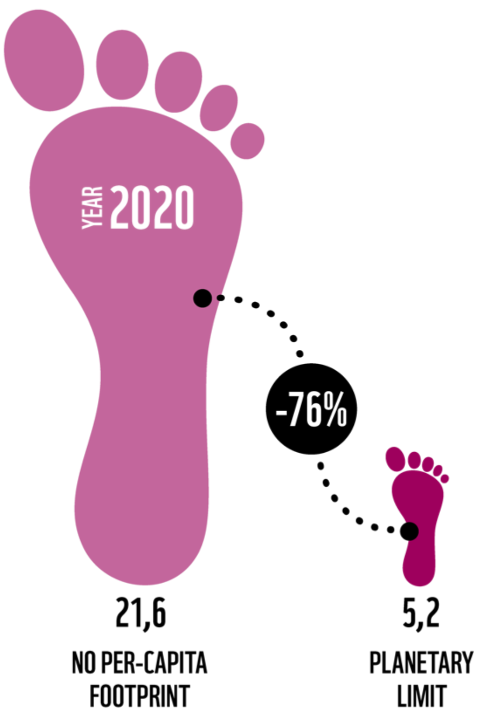


***Figure 4** – Norway's ecological footprint by type*[35]

MATERIAL FOOTPRINT



Target: reduce Norway's material footprint by 76% by 2030

The material footprint refers to the total amount of raw materials we extract for producing goods and services consumed in Norway. This consists of four main categories of resources: non-metal ores (mined minerals, stone, sand, and other equivalent raw materials), metal ores, biomass (food-, forest, and other plant or animal-based products), and fossil fuels[36]. In this report, biomass is excluded and treated as a separate footprint for analytical purposes, allowing for a better deep dive into its impacts and solutions.

However, it is important to remember that typically, for example when talking about the global Sustainable Development Goal 12, and its indicator on reducing the material footprint, the term refers to the standard definition, which includes all four categories.

Material footprint measures the total amount of tonnes of resources extracted. This measure implies that all the different materials are counted as the same metric. It does not differentiate between one tonne of sand or oil nor distinguish between the associated impact, such as emissions or pollution. For example, it only counts the tonnes of fossil fuels consumed in a wide range of industries, from plastics to energy. While the CO_2 emissions associated with the consumption of material resources are not included in the material footprint, but in the greenhouse gas footprint.

It is important to note that the available data has some limitations: our study relies on the Material flow analysis published by Statistics Norway (SSB). The SSB data includes all raw materials extracted, imported and exported. However, the data accounts consist only of primary raw materials, hence they do not include the materials embedded in imported goods (i.e., the metals and minerals in a car or mobile phone). Neither does it provide any consistent account of raw materials embedded in exports. It is therefore impossible to pinpoint precisely how much of the raw materials are consumed in Norway or if they are used for industrial production and exports. For a complete account of our material footprint, an augmented material flow analysis would have to be made, where material equivalent factors for all import and export categories are calculated. Still, the material footprint depicted provides an approximation of our total resource consumption and is a powerful tool for understanding our consumption of natural resources in Norway and its consequences.

DEFINING A SAFE LIMIT

Like the ecological footprint, the material footprint is not directly linked to one planetary boundary. But it measures the extraction of raw materials in an economy, which can be seen as an underlying driver for a range of different processes and activities pushing the planetary boundaries and the overall ecological footprint. In general, raw-material extraction is a driver for land and marine system change and degradation, causing biodiversity loss. Growing demand for minerals and increased mining activity are shown to contribute to rises in greenhouse gas emissions, acidification of water and other aquatic eco-toxicity, as well as emissions of smog-forming substances[37].

The UN's International Resource Panel (IRP) has warned that it will be impossible to reach the global Sustainable Development Goals (SDGs) without addressing the burgeoning global resource use. Material footprint (including biomass) is a key indicator for SDG #12, responsible production and consumption, to ensure sustainable consumption and production patterns by 2030.

While the SDG indicator does not specify a quantitative target, there has still been considerable research on what could be constituted as a safe per capita limit on material consumption.
The notion of a safe limit for the material footprint can be simply explained as accounting for all the consequences of raw material extraction on the natural environment versus all available deposits or productive areas. The raw materials included in this section are primarily extracted through mining or digging, consisting of metals, minerals, stone and similar. Biomass-related materials, like food, forestry products or cotton, are accounted for in the biomass footprint.

As material use grows, mining and other extractive industries extend into new areas and more inefficient forms of material extraction. This means that the corresponding impact will be increasingly negative, as additional production will require higher energy consumption and increasingly will come at odds with untouched high-value nature and protected water areas.

This does not discount the possibility of increasing extraction or opening new areas under stricter sustainability guidelines. However, it does indicate that there will be an on-aggregate level of extraction that will inevitably lead to disastrous consequences for nature if material resource consumption is left to grow unchecked[38].

UNEP's resource panel first suggested that the safe per capita limit for material consumption lay between 6-8 tonnes per capita, a point that would lead towards a decoupling of natural resource consumption and towards a path of global halving. This has later been revised by other researchers, who have suggested a lower limit of 6.4 tonnes per capita per year due to increased population growth estimates. The global biomass proportion of the total material footprint is estimated to be approximately 20%[39]. As our material footprint does not include biomass materials, this fraction has been extracted, which gives us a safe limit of 5.2 tonnes per capita per year.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NORWAY'S MATERIAL FOOTPRINT

Not surprisingly, Norway has a high material footprint that massively contributes to overshooting the planetary boundaries. To reach a level that is compatible with the safe operating space, a reduction of 76% is required.

While material footprints roughly follow indicators such as GDP, Norway is still at levels exceeding many European peers. Norway's material footprint, here counted as the consumption of fossil fuels, metals and non-metallic minerals, was 21.6 tonnes per person in 2021. Shockingly this is over twice the average EU level at 10.2 tonnes[40]. This is again nearly four times larger than the global "safe level" of 5.2 tonnes per person required to stay within the planetary boundaries[iii].

Overall, the material footprint is increasing. Figure 5 below shows an increase in Norway's consumption of materials by around 1.5 million tonnes per year. This constitutes around 10% growth since 2006. In the same period, resource productivity has seen a slight decrease, meaning we produce less growth per tonne of resource consumed.

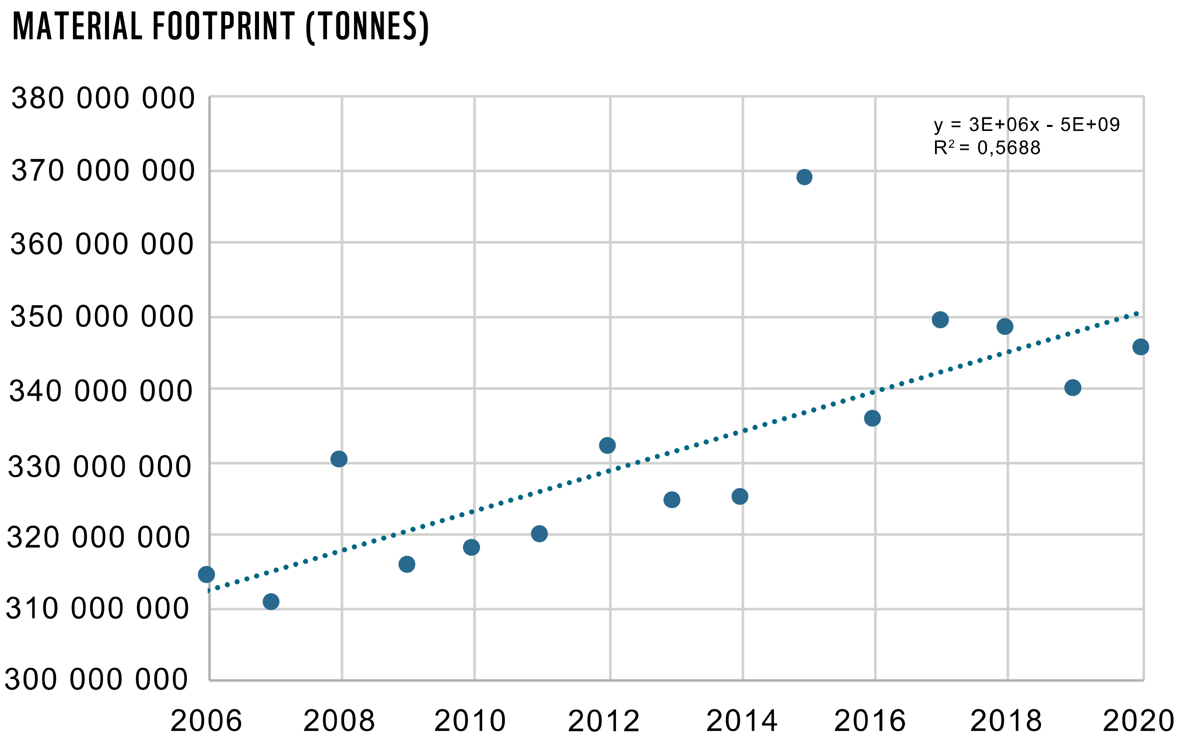

Figure 5: *Norway's consumption of materials per year.*

[iii] UN SDG Indicators[iii] https://unstats.un.org/sdgs/report/2019/goal-12/. Non-biomass assumed to be 80% of global overall material footprint (18.7 billion tonnes in 2020, following Fridolin Krausmann, Karl-Heinz Erb, Simone Gingrich, Christian Lauk, Helmut Haberl, (2008). Global patterns of socioeconomic biomass flows in the year 2000: A comprehensive assessment of supply, consumption and constraints, Ecological Economics, Volume 65, Issue 3, pp 471.

The largest share of Norway's material footprint comes from the extraction of fossil fuels such as oil and gas (Figure 6). The extraction of oil and gas has well known consequences for the climate and environment. Both emissions and oil installations contribute to chemical pollution and drive demand for building materials such as steel and concrete. Again, it is important to note that this account primarily from the production of the material resource, burning fossil fuels for other uses is not accounted for here and will be covered in the greenhouse gas footprint.

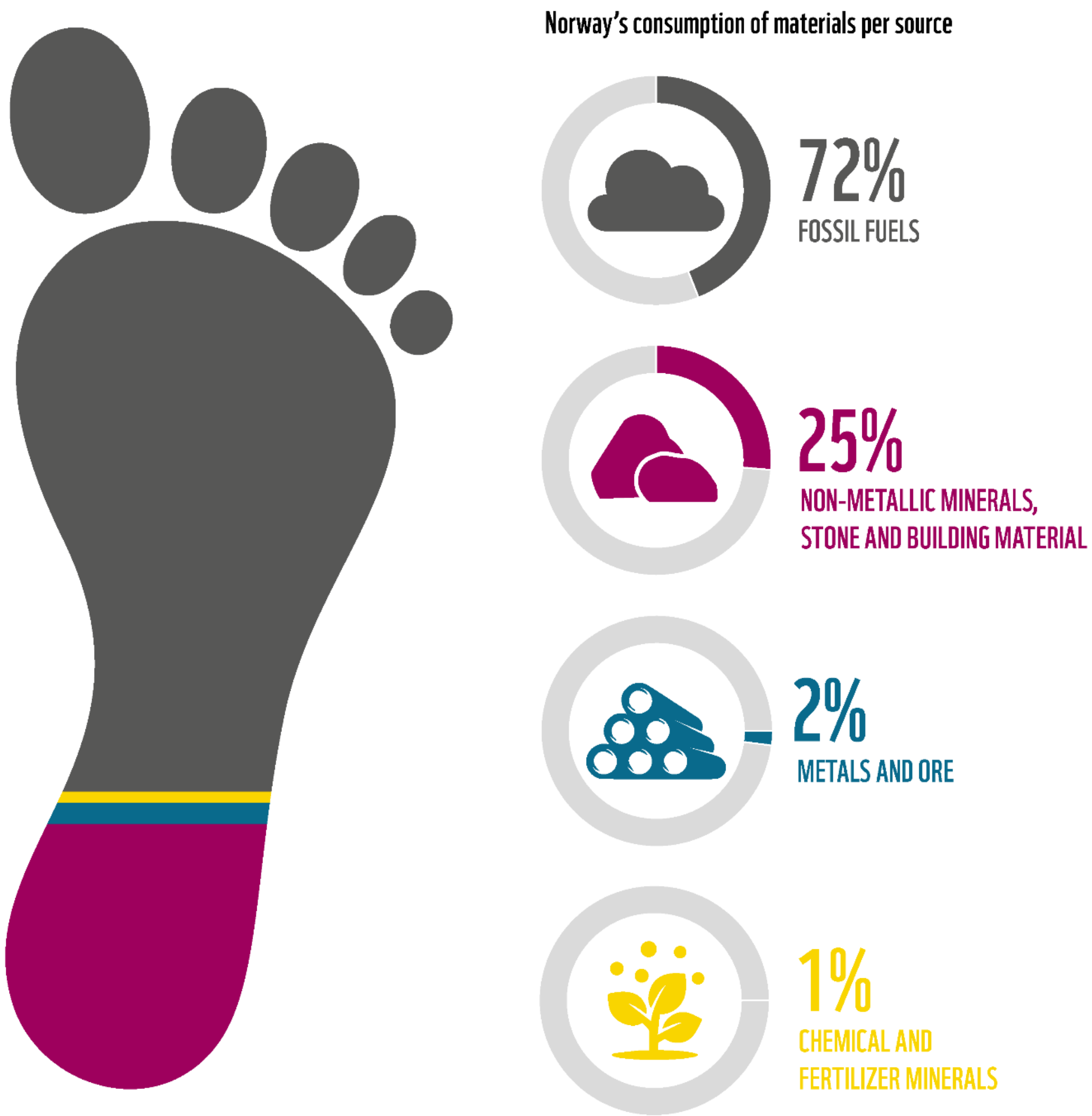

Figure 6: *Norway's consumption of materials per year. Reference year 2020.*

Construction and building materials, such as sand, stone, clay, chalk and gypsum, make up approximately 25% of the total material footprint. These are produced both domestically and to a large degree imported.

Surprisingly, Norway, with its rich stone and sand deposits, imports nearly twice as much as is domestically produced. While seemingly inconspicuous, sand provides an example of how the rapid increase in material consumption leads to an adverse impact on nature. A global construction boom has led to high demand for sand, which is used for example in cement. According to the International Resource Panel, sand is extracted from rivers, beaches and the seabed. This erodes riverbanks and important natural habitats, impacting surrounding biodiversity, contaminating waters and increasing flood risks. In addition, sand is increasingly extracted and sold illegally, which may imply that the total impact of sand extraction on nature is even greater[41].

A third big category is metals and minerals, imported for use in the large metal sectors in Norway. Some is retained for domestic consumption, but a large part is also exported, which significantly lowers the total material footprint caused by metals and minerals.

Mining and processing metals is associated with various impacts throughout the value chain. Pollution from mining and processing of metals can lead to contamination of water, causing disruption of both freshwater and saltwater ecosystems. This pollution can often persist after the extraction has ended, e.g., heavy metals pollution from closed-down mines. Lastly, there are also high associated greenhouse gas emissions in processing and refining metals, particularly aluminum and steel[42].


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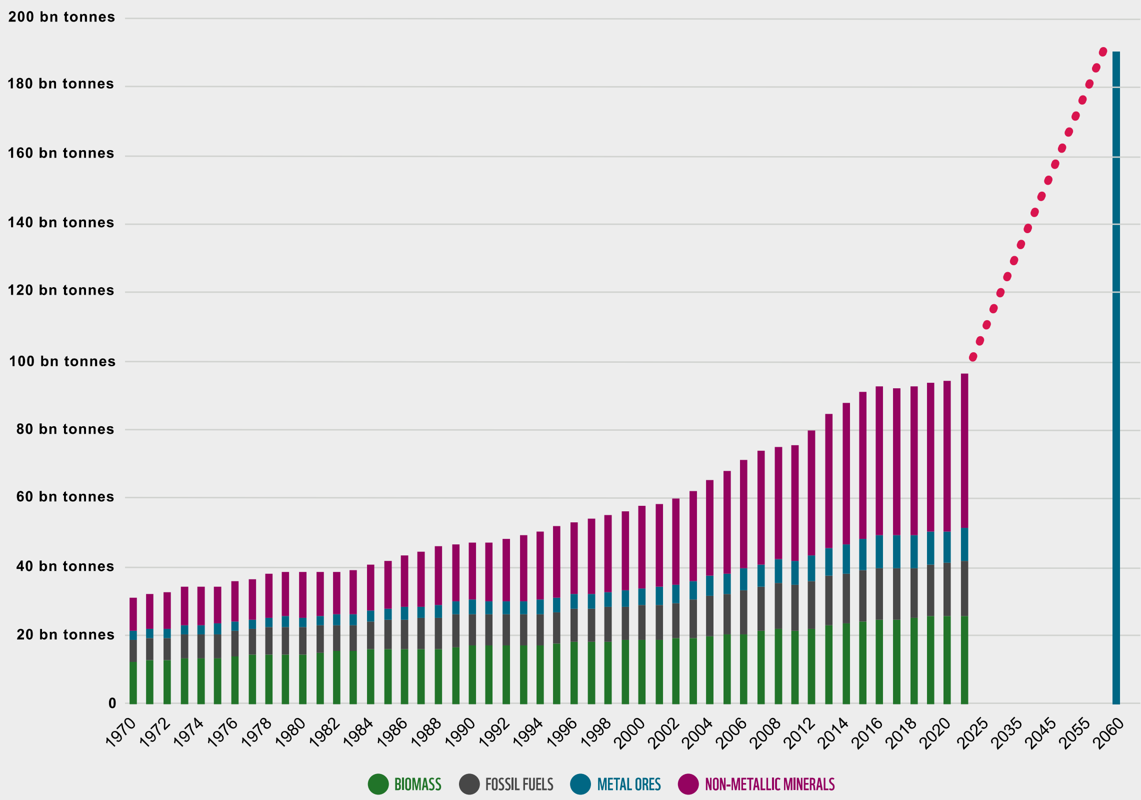
THE GLOBAL MATERIAL FOOTPRINT

The global material footprint, including all four categories of materials, rose from 47 billion tonnes in 1990 to 58 billion in 2000, and 96 billion in 2019, showing that the rate of natural resource extraction has accelerated significantly since 2000[43]. The footprint increased for all types of materials, but especially for non-metallic minerals (which accounted for almost half of the global footprint), pointing to growth in the areas of infrastructure and construction. In 2015, the material footprint per capita in high-income countries was more than ten times larger than in low-income countries, providing a striking picture of the uneven distribution of the responsibility for overshooting six out of nine planetary boundaries.

According to the UN, our material footprint is projected to grow to 190 billion tonnes by 2060, a level that will require not only that we extract more sustainably, but also reduce absolute consumption.

Halving the global material footprint means bringing today's consumption of 86 billion tonnes of materials down to 43 billion tonnes, i.e., the consumption level of 1990, while securing access to all essential goods and services. In what is clearly an oversimplification, this would mean that virtually each activity demanding new primary resources must halve its consumption through e.g., redesigning its business model.

***Figure 7** – Global material footprint,historical trend 1970-2019 and projection in 2060. Data from the International Resource Panel's "Global Material Flows Database", https://www.resourcepanel.org/global-material-flows-database*



The material footprint is directly associated with the extraction and consumption of virgin raw materials. Reducing the overall consumption levels is possible and feasible but halving the footprint from materials is not the same as halving the overall consumption in an economy. Rather the solutions are found within a circular-economic framework: resource efficiency, reducing overall demand for new materials, as well as recycling and reuse of materials to replace the need for new, virgin minerals will help lower the footprint. Lastly, there is a need to operate with strict requirements for sustainability and natural resource governance to extract minerals and materials with the least amount of impact.

To reduce the material footprint of Norway specifically, it is natural to start with the major components of the national material consumption. The largest category, fossil fuels, is a natural part of the broader discussion around climate transition and will be discussed under the greenhouse gas footprint. This leaves minerals, mining, and the wider category related to building materials.

METALS WITH LESS MINING IMPACT

Norway is a big consumer of metals both for industrial production as well as domestic consumption. Through strategies of reducing, recycling and reusing metals and minerals, we can significantly reduce our material footprint.

Today, primary metals have a high degree of recycling. For example, nearly all aluminum scrap is recycled and reused in new aluminum products. Theoretically endlessly reusable, some aluminum is still hard to recover because products are contaminated with other materials. Here new technology for material recovery, product design and innovative smelting processes can achieve near zero-emission aluminum, which is also closed-loop.

Similar targets should be explored for more metal streams, not the least for so-called critical minerals necessary for building new green technologies like batteries, green hydrogen or renewables. This will cover a more extensive range of industries, such as information technology, the energy sector, and waste management, which will need to cooperate to provide solutions to facilitate urban mining and recycling of mineral and metal components.

SUSTAINABLE AND CIRCULAR BUILDING MATERIALS

Non-metallic minerals account for 32% of Norway's total material footprint when biomass is excluded, the majority of which is used in construction. This contributes to a large part of the material footprint along the value chain of different materials, from extraction and production to waste.

Today, as much as 3,329,000 tonnes of building materials from the construction sector ends up as waste. This constitutes 29% of Norway's total waste. About 50% percent of this is recycled[44], falling short of the current target of 60% of the requirement from the Norwegian building code (Tek7). The rest is usually sent to landfills, often due to contamination with other materials. It is important to note that this includes building materials from biomass, such as wood, which is primarily sent to energy recovery (i.e., burnt).

This means that there is a great potential for reducing the consumption of virgin materials; by being better at utilizing the resources available, recycling and reusing. It also means that we should reduce demand: less demolition of buildings, more reused materials, and better design for longer building lifetime and easier recycling of materials.

To increase recycling and reuse of materials, new policy is needed to strengthen and facilitate the demand for secondary products. This means setting up regulations and easier testing that can allow for safe re-use of secondary materials, as well as making databases that collect information on available building materials. In addition, economic incentives must be considered – a fee on virgin materials or a target requirement for use of secondary building materials, financial support for new technology or facilitation of storing and collecting new material streams, and active use of public and private procurement[45].

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CIRCULAR ECONOMICS CAN AVOID THE NEED FOR TAKING EXTRACTION TO NEW DEPTHS

The prospects of mining minerals on the deep seabed provide an example of how an increase in demand for minerals can lead to conflict with untouched and valuable nature.

Many are estimating that the green transition will require vast amounts of minerals, with demand expected to overshoot the current supply. In a worst-case scenario this could endanger the transition, as some of the minerals are essential components in renewable and clean energy technologies, such as; wind turbines, electricity networks and electric vehicles. The expected demand and potential bottlenecks are leading to a push to open new areas for extraction to cover the demand.

One such example is deep sea mining. While today not technically possible, several startup companies are attempting to push for opening areas for deep sea extraction worldwide. Using the green transition as a justification, they even market these minerals as green or sustainable and invaluable, despite little knowledge of nature and biodiversity in the relevant area and how it could potentially be impacted by a new industry.

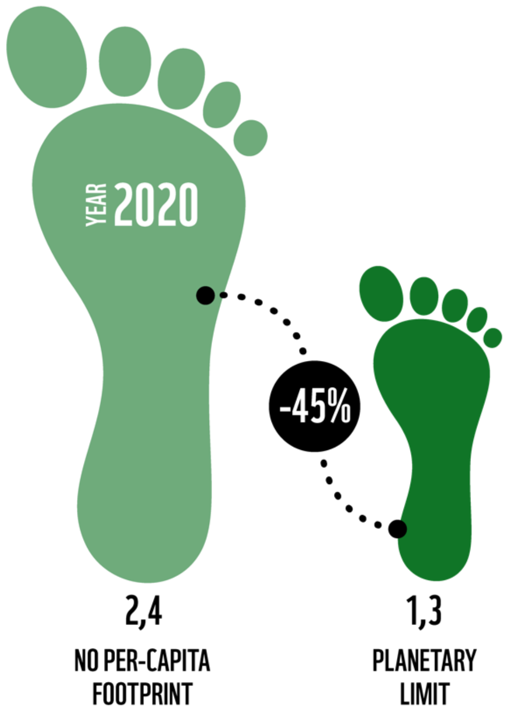
What is known is that the deep ocean ecology is highly vulnerable, leading existing scientist to warn against large scale biodiversity loss due to the mining process itself, where the seabed is destroyed to extract ore, or from the associated pollution of for instance noise, light or sediments. This can also cause increased atmospheric emissions, due to disturbance of carbon stored in sediments at the seabed.

This has led the UN Ocean panel to declare that seabed mining could not be part of a sustainable blue economy, and big financial institutions like the European Investment bank to exclude the industry due to unacceptable climate and environmental issues[46].

A more sustainable response would be based on recycling and reducing and responsible innovation. Much of the mineral need can likely be reduced by developing new renewable technologies that have different and less demand for critical minerals. Similarly, a focus on product life, recycling and reuse, along with circular strategies like sharing, this could potentially go a long way in meeting future mineral demand as stocks in circulation of important minerals grow. While new mining would be necessary in the short term, this could be met by developing existing reserves in the most sustainable way possible.

Opening new untouched areas like the deep seabed for extraction should be avoided, as it would contribute towards increasing our footprint and would compete to undercut more sustainable circular solutions.

BIOMASS FOOTPRINT



Target: reduce biomass use by 45% by 2030

The biomass consumption footprint is the proportion of global production or extraction of biomass-based materials attributable to a country's domestic demand. It is a subset of the material footprint and relates to the consumption of agricultural products, animal products, forest products, fishery products and aquaculture products, measured in volume (tonnes per year). As with the other footprints, it covers both materials produced within Norway and imported from overseas, but not those exported.

Due to the lack of data for certain categories in the material flow analysis published by Statistics Norway (SSB), the biomass footprint does not include domestically produced live animals and animal products (with the exemption of fish and aquatic animals), or products mainly from biomass, but the import of these groups of biomass products are included. The impacts of the production or extraction of biomass-based materials, such as greenhouse gas emissions, land-use change, water use, pollution and eutrophication, are not directly encompassed in this footprint but instead covered under the Greenhouse Gas Footprint or the other not yet quantified footprints/other important drivers, pressures, and states. Biomass consumption is unsustainable because of these impacts, but it is worth addressing them separately. Because even if we implement every measure to reduce the negative impacts of production or extraction of biomass materials, we use up much available arable land to produce these resources. Only a reduction of the biomass footprint in terms of total biomass resource consumption will give room for nature and leave room to feed a growing population within planetary limits.

HOW DOES THIS FOOTPRINT IMPACT NATURE?

The biomass footprint tells an essential part of the story behind the rapid decline in biodiversity that we see both in Norway and worldwide. As we continue to consume more globally and develop more efficient techniques of harvesting and extraction, the biomass footprint, and the negative impacts of our extraction and production, increases.

Natural resource use and overexploitation is the second most significant driver of biodiversity loss[47], after land-use change. Harvesting populations beyond a sustainable level can diminish numbers to the point that organisms can no longer replenish themselves naturally, which can have devastating effects on individual species and cascading impacts on ecosystems. Some of the most overexploited species are trees, species harvested for the medicinal and pet trade, and marine fish. One of the key impacts of marine resource consumption is the depletion of animal and plant stocks. Global demand for marine resources is growing, putting increasing pressure on stocks. For example, over one-third of global fish stocks are estimated to be exploited above biologically sustainable levels.

DEFINING A SAFE LIMIT

As with the ecological and material footprint, the biomass footprint is not directly linked to one planetary boundary. However, production and consumption of biomass is closely correlated to a wider range of negative outcomes that put pressure on many of the nine planetary boundaries. It is therefore possible to define an aggregated estimation of how biomass consumption in general, across categories, contribute to the various planetary boundaries. As for every limit, there is of course a variation in the degree they are affected by biomass consumption. However, the planetary limit represented is set at a level which would reduce pressure across them all.

The per-capita limit for biomass was drawn from the same analysis as a subset of material footprint. The limit for the entire material footprint (non-biomass + biomass resources) was set at 6.4 tonnes per capita annually[48]. Because of the lack of accurate data, the average share of biomass in the material footprint is based on the best scientific literature and is estimated to be approximately 20%[49]. This provides us with a safe planetary limit for the biomass footprint of 1.3 tonnes per capita per year.

The limit is, of course, sensitive to technological changes, as well as changes in social and economic circumstances (i.e., less or more population growth, or failure to distribute and develop resources). However, the law of big numbers still provides us with a clear view of what would happen to the planetary boundaries should we fail to either apply new and innovative production methods for better sustainability or reduce the overall consumption of biomass. As such, the notion of a per capita cap indicating a safe operating space for biomass consumption is well grounded in a precautionary principle to sustainable nature management.

NORWAY'S BIOMASS FOOTPRINT

In 2020, Norway had a biomass footprint of 2.4 tonnes per person per year. The safe planetary limit is 1.3 tonnes per capita per year. To be within a safe limit, we need to reduce our biomass material production and consumption by 1.1 tonnes (43%) per capita per year.

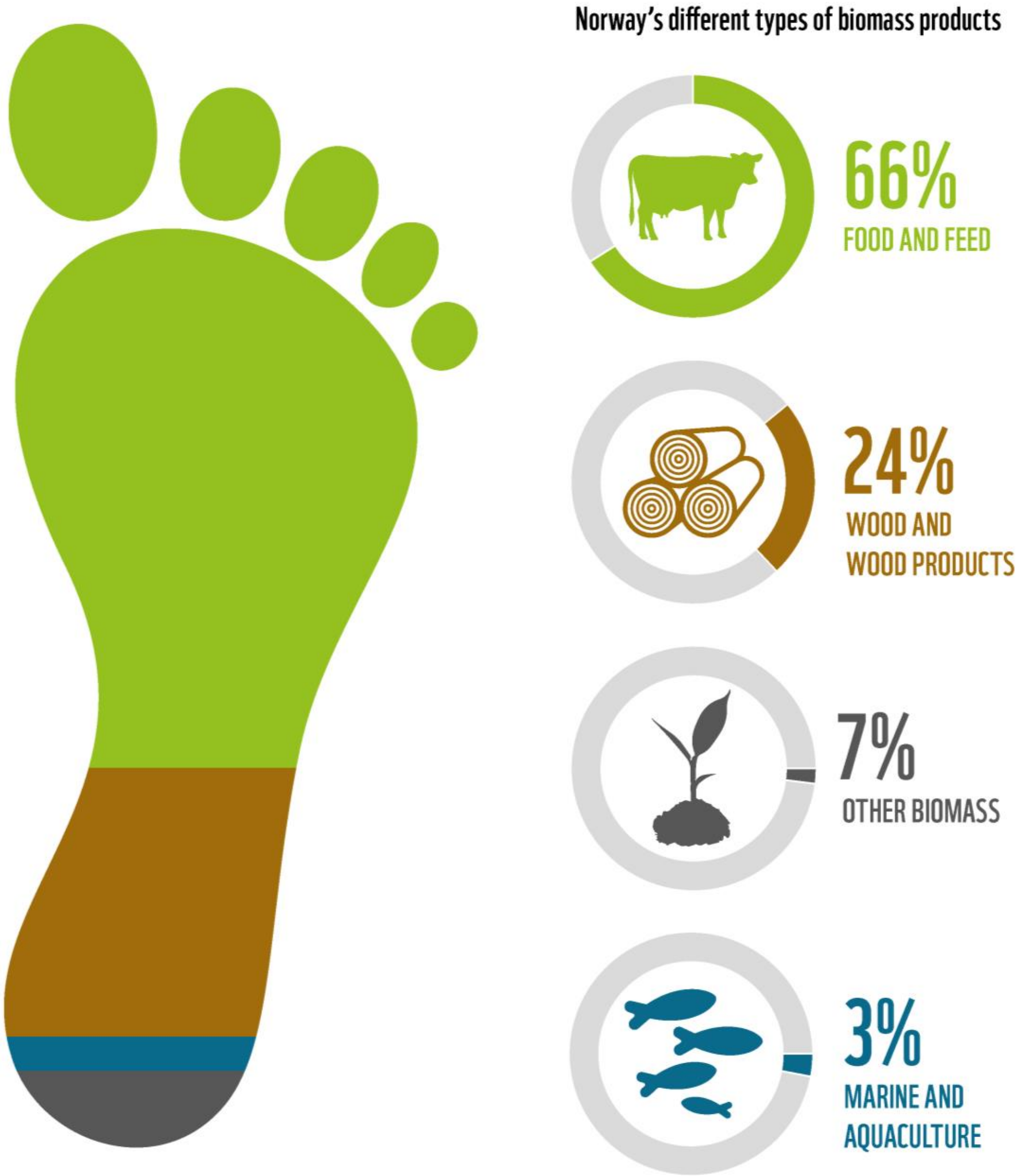


Figure 8 *- Shows how Norway's biomass footprint is divided between different types of biomass products.*

According to the material flow account numbers presented by SSB, Norway largely consumes nationally extracted and produced biomass products, and only a smaller percentage of the biomass footprint is imported.

In our analysis, we found that approximately 69% of Norway's overall biomass footprint is related to products we eat directly or use to produce food. Regarding goods such as fish, meat, and dairy, we have a large domestic production. However, in some sectors, such as the food sector, we heavily rely on imports of certain goods. It is estimated that about 46% of the food consumed in Norway is produced within the country[50]. This number is reduced to 40% when we include the animal and fish feed imported from abroad to make this food. The rest is imported from abroad[51]. But we rely on imports of crops we cannot produce ourselves, such as sugar and several types of grains[52]. Animal protein, feed and fodder account for around 36% of Norway's biomass footprint[53]. The figure would likely be higher if we included domestic meat production as most of the meat consumed in Norway comes from domestic production, and only a small share of the meat is imported[54]. However, there has been an increase in meat imports in recent years[55]. The total meat consumption in Norway was around 75 kg per capita in 2020.

Wood and wood products account for 24% of Norway's Biomass Footprint[56]. This is the second largest fraction of our biomass footprint.

As mentioned, exports are not included as part of a country's footprint, but it might be worth mentioning that as much as approximately 70% of the biomass that is extracted nationally is exported. Particularly the export of fish is a large part of this.

MARINE RESOURCE DEEP DIVE

Marine resources, the marine proportion of the 'wild catch and harvest' fraction of Norway's biomass footprint, comprise approximately 3.2% of Norway's biomass footprint. It includes imported and domestically produced marine fishery products, aquaculture products, and aquatic plants for direct consumption (e.g., eating of fin fish, shellfish, and seaweed), as well as marine resources embodied within other products, such as fish feed and fish oils used in livestock production. It does not include feed used in aquaculture. In comparison, marine resources are 1.1% of the global biomass footprint.

Throughout its history, fishery has been a major industry in Norway. According to FAO statistics, in 2018, Norway was the 9th largest capture fishery and the 7th largest aquaculture producer in the world. Norway produces around 2.3 million tonnes of wild captured fish, 1.4 million tonnes of marine aquaculture products and imports 0.6 million tonnes of fish products (including fish meal and oil used as aquaculture feed). It exports around 2.3 million tonnes of fisheries and aquaculture products.

It might therefore seem surprising that marine resources do not make up more than 3.2% of the biodiversity footprint. However, Norway exports a large amount of the fishery products we extract. Approximately 93% of the national extraction of fish capture and aquatic animals and plants are exported. These exported products are not counted in Norway's biomass footprint but would instead form part of the footprints of consuming countries. The biomass footprint of unreported bycatch of fish species, marine mammals, and invertebrates such as corals and sponges are also not included in this report.

HOW WE CAN REDUCE OUR BIOMASS FOOTPRINT BY 45%

As for all footprints, our overall consumption needs to go down. But we need to continue to extract and consume new raw materials, and we need food. How we extract and produce products is crucial for our consumption's effect on nature. We need to be better at optimizing our extraction and production in a way that minimizes the pressure on nature and is sustainable. Managing where and how we produce which products is important to lessen impact and optimize the production of required materials. The way we then use the materials must be maximized in order to reduce the need for new materials into our overall consumption. By producing more out of less, increasing the lifetime of products, reducing waste in all stages of production and recycling waste and materials. Some of the more significant transformative changes necessary to do this are described in the last part of this report.

Food

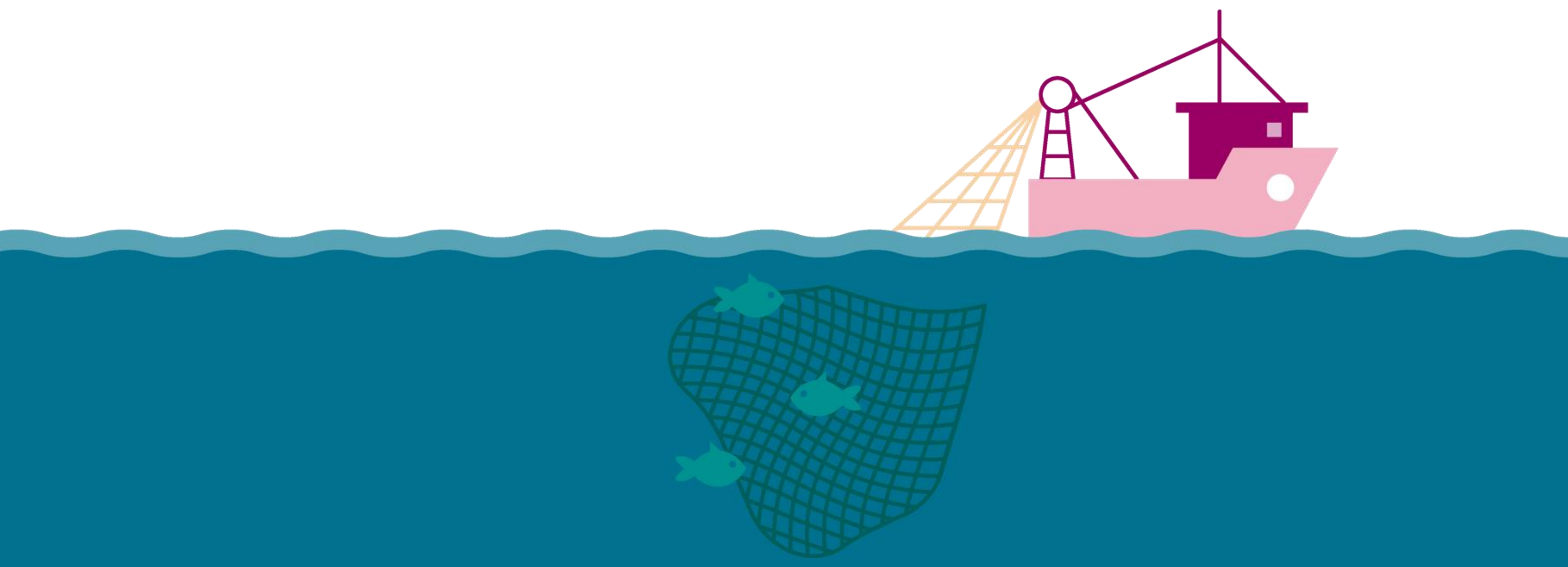
Considering the amount of the biomass footprint that originates from products we either eat directly or use to produce food (approximately 69%)[57], it is evident that we need to look at what we eat and where and how our food is produced. The need for transforming our food system is further explained under "Food system transformation".

We also throw away a lot of food. As much as 1.1 million kg of edible food is wasted every day[58], and the total food waste in Norway was estimated at 417,000 tonnes in 2019, equivalent to 78 kg per capita per year[59]. Although this amounts to just 3% of all waste, it is around 12% of all biomass waste[60]. Households account for about half of post-harvest food waste (55%), followed by producers (22%), retailers (15%), hotels and catering (7%), and wholesalers (1%)[61].

Norway has an existing commitment between the food sector and the government to reduce post-farmgate food waste by 15% by 2020, 30% by 2025, and 50% by 2030[62]. The food waste was reduced by 12% between 2015 and 2019[63], meaning the 2020 target was not reached. Other European countries, such as France and Italy, have set laws regulating food waste to tackle the problem. The Norwegian government is currently reviewing how food waste legislation might look for Norway. Meanwhile, the Norwegian NGO Future in Our Hands has given a detailed proposal on how a food waste law could function in Norway[64].

Aquaculture

As already mentioned, a lot of the fishery and aquaculture products produced in Norway are exported, and the biomass resources used in the production of, e.g., Atlantic Salmon, are therefore not accounted for as part of the Norwegian footprint. Even so, the production also affects the stocks and health of wild domestic fish, other marine organisms and ecosystems, and an effort must be made to reduce the impact of the production. The industry needs to apply technology that stops spread of sea lice, minimizes the possibilities for escapes, minimizes the need for the fishing of cleaner fish such as different wrasses and doesn't pollute fjord systems or offshore areas with medicines, feed spill or other waste products.



Harvesting methods in the fishing industry

Active fishing methods such as bottom trawling and dredging have significantly impacted biodiversity over the years, destroying habitats at the ocean floor. Newly described science has also pointed to these fishing methods as a source of increased ocean acidification through GHG emissions by disturbing the carbon storage in the sediments on the ocean floor.

Bycatch is also a huge global problem contributing to endangering species such as sharks, whales and dolphins. For many species (e.g., porpoises), bycatch should ideally be less than 1% of the best available abundance estimate and, ultimately, be reduced to zero. One of the main challenges with bycatch is that it affects species with poor or no regulations, such as the Angler (*Lophius piscatorius*) and Wolffish (*Anarhichadidae*) in Norway. It also contributes to a further depletion of the stocks of already threatened species, such as the golden redfish (*Sebastes norvegicus*) which is listed as vulnerable in both the Norwegian and IUCN Red List.

The knowledge on levels of bycatch for some species is very limited, especially if it is not commercially interesting fish species, or corals and sponges. The full effect of the problem on the marine ecosystem, both in Norway and globally, is therefore not fully known.

In Norway, the harvesting and fishing quota regulation is based on single-stock models for the commercial target species, not multi-species models. These models do not include either other target species or non-commercially interesting species.

The Norwegian fisheries should fully transition to low-impact fisheries, with no use of non-selective and destructive fishing gears and techniques in protected Norwegian waters and by Norwegian vessels, including distant water fleets. The government needs to shift from single stock to multi-species models when calculating sustainable yield and setting fishing quotas.

Recycling of biomass materials

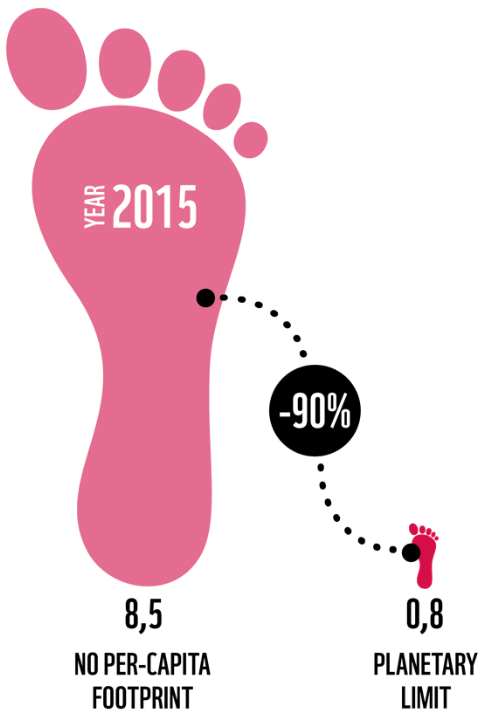
We need to be much better at reusing and recycling biomass materials. Such as textiles, wood and wood products.

Textiles comprise only a small proportion of Norway's total biomass footprint and annual biomass waste. Still, as much as 67% of waste textiles are sent to landfill, incinerated, or disposed of by unknown means[65]. The ministry of climate and environment has recently set up a working group to tackle to problem with an increasing amount of textile waste in Norway. This group will most likely propose a strong scheme for extended producer responsibility targeting the textile sector, which is long overdue[66].

Over 818,000 tonnes of wood waste are generated annually in Norway (2020), and only 11% sent for material recovery. If we recirculate more wood and wood-based products such as paper, we will be able to reduce the need for new materials and reduce the pressure on forests. Fortunately, there has been more attention on the opportunities in reusing and recirculating wood waste. There is for example an ongoing governmentally supported project, SirkTRE, which goal is to establish a fully circular value chain and quadruple the reuse of wood within the next ten years.

Andre Kohen / Shutterstock

PHOSPHORUS FOOTPRINT



Target: reduce phosphorus use by 90% by 2030

Based on consumption data, the phosphorus footprint measures how much phosphorus fertilizer is applied to cropland. Phosphorus is one of the critical inputs to produce synthetic fertilizers and a key nutrient in organic fertilizers (manure). A large proportion of fertilizers originates from phosphate rock resources, with about 80% mined in a handful of countries: China, Morocco, Western Sahara, USA, and Russia[iv]. This exposes fertilizer use to international geopolitical and market risks, as well as to the fact that sources of mined phosphate rock are finite and could become depleted in time.

[iv] Unless otherwise specified, all data and information on phosphorous extraction and impacts are taken from IRP (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.

HOW DOES THIS FOOTPRINT IMPACT NATURE?

While phosphorus has had a key contribution to food security worldwide, its systematic use and overuse is problematic at all stages of its lifecycle: from mining to fertilizer production and application on agricultural fields. At its source, the mining of phosphates rocks can lead to pollution as heavy metals and other potentially harmful substances are released into the environment.[67] Contaminants in the phosphate rock, such as cadmium, uranium, chromium, and radioactive substances, often end up in manufactured mineral fertilizers. At the same time, cleaner resources are mainly used as feedstock in the chemical industry. The application of contaminated fertilizers can lead to ecological and human toxicity effects, as these accumulate in soil and can be taken up by crops or leach into water bodies.

The production of phosphate fertilizer requires numerous chemicals and has high material and energy needs, contributing to emissions of greenhouse gases and particulate matter.

A final issue is that only a relatively small amount of fertilizers is absorbed by plants, with the remaining fertilizer often ending up in rivers, lakes and fjords through runoff and leaching, where it causes eutrophication[68]. This is especially true for agricultural areas that have been intensively managed for long periods.

DEFINING A SAFE LIMIT

Phosphorus is directly linked to one of the planetary boundaries. The boundary, or safe limit, could be summarised as *'the point at which the risk of a large-scale ocean anoxic event (*a situation where parts of the ocean are deprived of oxygen and become acidic to the point of toxicity) *and/or the risk of widespread eutrophication of freshwater systems* becomes *more than zero'*. The planetary boundary for the phosphorus footprint concerns the use of phosphorus in agriculture, which accounts for the predominant 'release' of excess nutrients into the global nutrient cycles. The per capita planetary boundary has been calculated to be approximately 0.8 kg P per capita per year[69].

NORWAY'S PHOSPHORUS FOOTPRINT

Norway has a phosphorus footprint of 8.5 kg per capita per year. This is well above the planetary boundary of 0.8 kg per capita per year, and a significant reduction of 90% is needed to reduce the footprint below the safe limit. As a comparison, the per capita phosphorous consumption was 6.4 kg in Sweden and 4.9 kg in Denmark. France, a large agricultural nation, has a per capita footprint of 8 kg of phosphorus. According to Eurostat, Norway used 8 996 thousand tonnes of mineral fertilizer containing phosphorus in agriculture in 2020.

In the EU and Norway, almost all mineral fertilizers used in agriculture and industry are imported[70]. In 2020 Norway imported 2 330 thousand tonnes of chemical and fertilizer minerals. However, Norway also imports phosphate to produce fertilizers that then is exported, primarily by Yara, a company that produces, distributes, and sells mineral fertilizers. Only 10% of the mineral fertilizer produced in Norway is used nationally. In 2020 Norway exported 3 702 thousand tonnes of chemical and mineral fertilizers. For the Norwegian footprint, exports are not counted. As such, our overshoot of the planetary limit is due to import and domestic use of phosphorus, i.e., an overuse in agriculture.

A report from SSB estimated that 15 600 tonnes of phosphorus were added to agricultural land in Norway in 2018[71]. Half of all the phosphorus is not taken up by plants but instead remains in the soil or ends up in drainage systems[72].

There are also challenges related to the loss of phosphorus from the aquaculture sector. Yearly around 12 000 tonnes of phosphorus is added to fish feed[73], but research shows that 75% of this ends up as waste at the sea bottom. The scale of aquaculture production has increased in the last 20 – 30 years, making aquaculture the single most significant source of phosphorus released to Norwegian coastal areas, followed by municipal wastewater and agriculture. Aquaculture releases between 9 – 12 thousand tonnes of phosphorus to the sea each year[74]. The damage from the release of nutrients is greatest directly under and near the aquaculture farms. The damage is particularly great in areas where the water quality is bad or where water is still and rarely exchanged. The release of large amounts of nutrients under the farms can lead to algae which breaks down and reduces the oxygen level at the bottom of the sea[75].

REDUCING THE PHOSPHORUS FOOTPRINT BY 90%

There is a considerable potential to reduce our phosphorus footprint through a combination of lowering the primary need for fertilizers, as well as finding ways to recycle and use phosphorus more efficiently[76].

The primary way is to try to reduce the primary demand, so to reduce the overall footprint at its source. Adopting a set of agroecological practices that can improve the current industrial agriculture can have a relevant impact by decreasing the overall need for fertilizers through better management of soils, while also reducing runoff and leaching into soils and water bodies through, e.g., cover crops and mulching. This is described further in the section about Food system transformation.

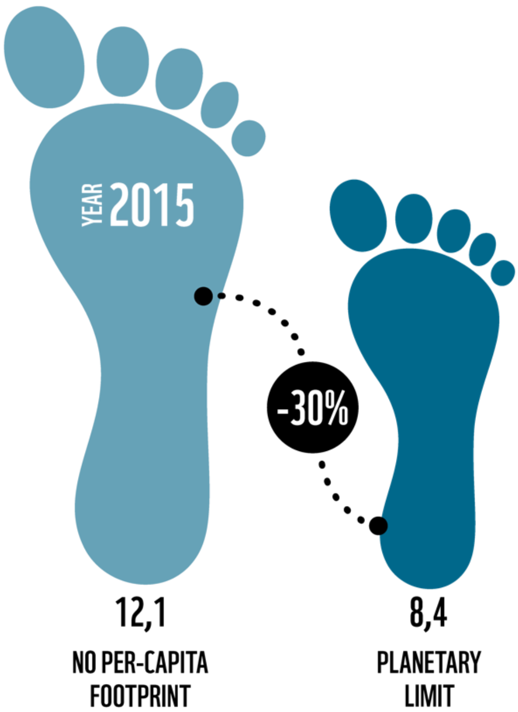
Reducing the loss is also imperative. An estimated 80-95% of primary phosphate is lost throughout the stages of phosphorus production and application and wastewater discharge from sewage treatment plants. Norway loses 1483 tonnes of phosphorus to wastewater[77], and hence the water industry is a key stakeholder in phosphorus management. Wastewater treatment could recover 95% of the phosphorus from urban wastewater and concentrate it into sewage sludge that, after appropriate treatment, can be applied to land as a nutrient-rich soil improver (biosolids) and/or into side-stream recovered phosphorus. Technologies are currently being developed for recovering phosphorus from wastewater directly. In this case we can look to our Swedish neighbours, who have introduced a law that targets phosphorus recycling in urban wastewater.

There is also a potential to use the waste of phosphorus from some sectors and recycle this. For example, there is a potential to recycle waste from aquaculture for use in fertilizers applied to cropland.

Finally, mining practices must be improved to minimize the risk of pollution and impacts on nature. Policymakers could introduce a threshold for heavy metals and other pollutants in mineral fertilizers.


David Bebber / WWF-UK

NITROGEN FOOTPRINT



Target: reduce nitrogen use by 30% by 2030

Nitrogen is another nutrient that is essential for all life on the planet. It is a part of the natural nutrient cycle, but too high levels can create problems especially in aquatic environments.

In the same way as with phosphorus, human activity is creating an imbalance in the natural cycles. Agriculture, deforestation, wastewater, and the use of fossil fuels are all factors that result in increased levels of nitrogen. The production and use of synthetic mineral fertilizers is also an important cause.

HOW DOES THIS FOOTPRINT IMPACT NATURE?[78]

While the production of phosphorous and potassium comes from the physical mining of potash and phosphate rocks, nitrogen is extracted from the air and, to be used as fertilizer, needs to be converted into reactive forms such as ammonia or nitrous oxide. This process is energy-intensive and dependent on fossil fuels, in particular natural gas, thus generating large quantities of greenhouse gases and accounting for up to 50% of the energy use of the agricultural sectors. Agriculture also accounts for 80% of total nitrous oxide (N_2O) emissions, a greenhouse gas 264 times more powerful than CO_2, mainly from synthetic nitrogen and manure application.

Globally, around 20% of all nitrogen fertilizers applied end up accumulating in soils and biomass, whereas 35% enter the oceans. This is in line with three studies in Norway, where the average nitrogen use efficiency (calculated as nitrogen removed in harvested grain divided by the amount of applied nitrogen) ranged from 61 to 71% for barley and from 67 to 82% for oats: in other words, 18-39% of nitrogen is lost. As for phosphate fertilizers, nitrogen fertilizers are a major cause of pollution to freshwater ecosystems and oceans, as rainfall causes them to leach into groundwater or run off into waterways, causing eutrophication. This makes nitrogen a significant driver of biodiversity loss through impacts such as acidification and eutrophication (see Water Pollution).

NITROGEN IN THE OSLO FJORD

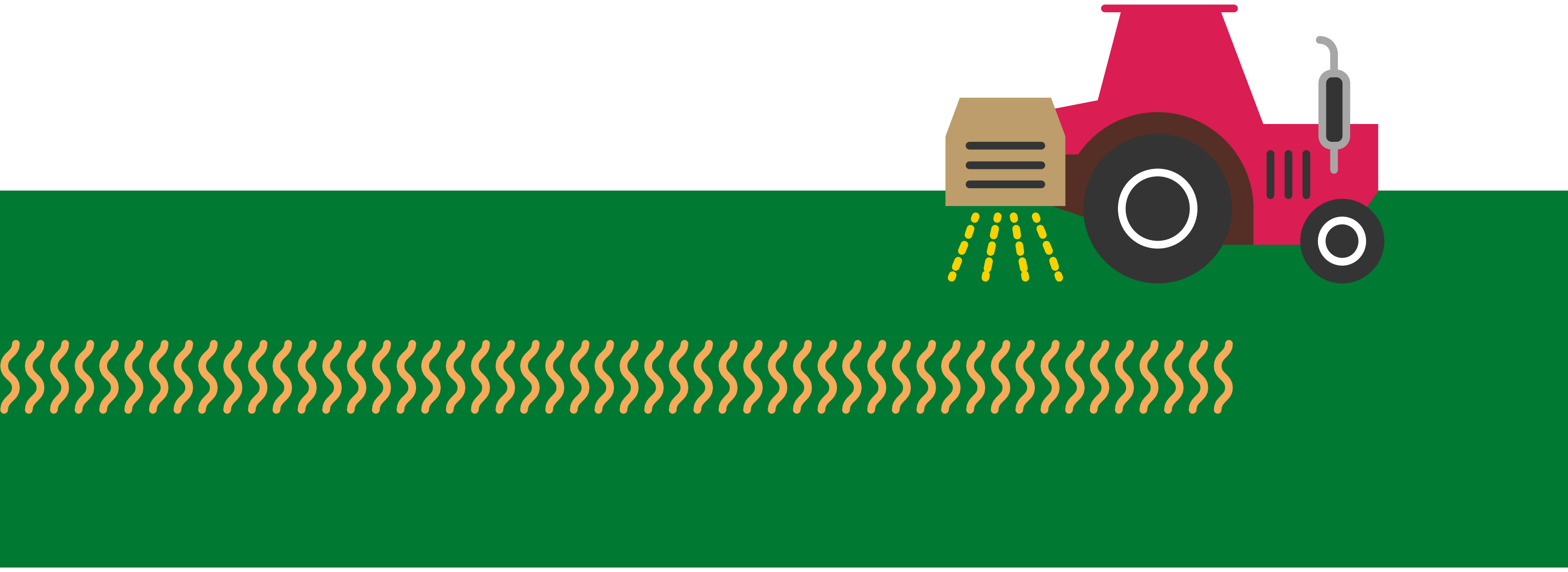
A recent report has concluded that the level of nitrogen in the Oslo Fjord is exceeding threshold values[79]. Amongst others the high nitrogen levels are resulting in types of algae that are negatively affecting ecosystems and in very low oxygen levels in parts of the fjord. The report found that the nitrogen is coming mainly from agriculture and wastewater that is flowing into the fjord[80]. Previously researchers thought that the nitrogen was brought from foreign countries by currents, but the report shows that the flow of nitrogen is coming from domestic activity[81]. The problems related to nitrogen vary between different parts of the fjord but in general the entirety of the fjord is affected to some degree. The report points out that the release of nitrogen into the fjord has increased significantly in the last 25 years and that population growth might contribute to an even greater flow of nitrogen in the future.

DEFINING A SAFE LIMIT

Nitrogen is directly linked to one of the planetary boundaries. The boundary, or safe limit, is set at a level at which there is a very low risk for eutrophication of aquatic ecosystem. The per capita safe planetary boundary is proposed to be 8.4 kg nitrogen from industrial and intentional biological N fixation per capita per year[82].

NORWAY'S NITROGEN FOOTPRINT

Norway has a nitrogen footprint of 12.1 kg nitrogen per capita per year. This is well above the planetary boundary of 8.4 kg nitrogen per capita per year and would require a 30% reduction to lie within a safe limit. The high use of fertilizers has large consequences for Norwegian nature. Data from the Norwegian Environment Agency shows that one-fourth of Norwegian land areas already receive more nitrogen from long-range transport and deposition of acidic nitrogen compounds than the vegetation can tolerate[83].



REDUCING THE NITROGEN FOOTPRINT BY 30%

Industrial agriculture depends on a systematic use of fertilizers – mainly nitrogen, potassium and phosphorous – to boost yield and to compensate for the progressive degradation of soil fertility.

In the period 1961-2014, global fertilizer use increased fivefold. However, it is clear that this dependence on synthetic fertilizers is not sustainable, and it poses long-term risks for food security and businesses. On-farm physical risks are related to how synthetic fertilizers impact soil biodiversity, disturbing the symbiotic relationships between plants and soil microbes. Furthermore, fertilizers contain no organic component, which leaves soils vulnerable to erosion and reduces their ability to hold water and nutrients, requiring more fertilizers to maintain production.

Fertilizers' dependence on fossil fuels is also a major risk, given the need to limit global warming in line with the Paris Agreement. However, all agricultural soils need some input to maintain fertility over time, either through organic or synthetic fertilizers. But this input can, and should, be achieved to a much higher degree through cover crops such as nitrogen-fixing plants, polyculture and crop rotation. This would reduce the need for nitrogen and phosphorous and progressively bring these two nutrient cycles back within planetary boundaries[84].

GREENHOUSE GAS FOOTPRINT

Target: reduce consumption-based emissions by 71% by 2030 and 86% by 2050

Among the footprints, the thematic of greenhouse gas emissions remains the most well-known and studied. However, it is usually studied in the way of national emission accounts that highlight the emissions originating from activity inside a single country.

A footprint approach relies on a consumption-based emissions account, which includes all domestic and imported emissions, excluding emissions related to exported goods. In other words, we count all the embedded emissions from goods and services that are consumed within Norway, including those that are produced outside of Norway.

Consumption-based emission accounts are currently not reported by the Norwegian government or Statistics Norway (SSB). However, the consumption-based account has been calculated for 2017. Using a multiregional input-output model, the Norwegian carbon footprint for 2017 was estimated to be 58.2

million tonnes CO_2-equivalent (MtCO2e), corresponding to 11.1 tonnes of CO_2e per person[85]. This is higher by 11% than the 52.4 Gt CO_2e featured in national emissions accounts.

DEFINING A SAFE LIMIT

Climate science has provided us with perhaps the clearest picture of our relationship with the planetary boundary. The Intergovernmental Panel on Climate Change (IPCC) has developed a range of trajectories for emissions, impacts and mitigative scenarios, detailing the expected global warming caused by various emission levels. A maximum increase of 1.5 degrees Celsius has become the prevailing target for climate policy. While all temperature increase is associated with negative implications for humans and nature, limiting to 1.5 degrees Celsius in global warming is the least-worst that can be achieved with mitigative strategies at this point. There is also the notion of higher increases that would increase the chances of so-called tipping points, where the consequences of global warming would reinforce themselves, such as through melting of permafrost, changing of currents, or loss of snow-cover that currently deflect sunlight.

The IPCC provides corresponding carbon budgets associated with limiting global warming to 1.5 degrees Celsius, allowing us to calculate the per-capita levels of emissions. Currently this number is estimated to be 3.2 tonnes of CO2e annually per capita by 2030, and 1,5 tonnes of CO2e by 2050[86].

NORWAY'S CONSUMPTION-BASED CARBON FOOTPRINT

A consumption-based approach provides us with a different perspective than national accounts, as it specifies products and services rather than sectors. Of the 58.2 MtCO2e, 42% of these emissions consisted of emissions abroad, occurring in the supply chains of products ultimately consumed in Norway.

Currently, the largest part of our carbon footprint comes from transportation of around 2.7 tonnes of CO2e per capita. The second largest component comes from food and drink at around 1.7 tonnes of CO2e. After that, housing and energy are at around 0.7 tonnes, while basic commodities are right under 0.5 tonnes of CO2e. This again can be broken down both in terms of sector origin and country of origin in terms of imports. Particularly agriculture stand out as large sectoral origin of domestic emissions, with 15%. In addition, power-intensive industries, as well as energy, contribute around 11% and 10% respectively[87].

Even if it is not included in the material footprint, the exported emissions from Norway provide an important sense of perspective. As a major exporter of oil and gas, as well as other energy-intensive products like aluminum, we have large domestic production emissions embedded in our export products. In fact, emissions from the export-oriented petroleum and industry sector make up respectively 25% and 24% of Norway's total national emissions. Even so, our imported emissions overshoot the national emission account by 9 tonnes CO2e, or about 18.5%.

The perhaps biggest elephant in the room are the emissions from use of oil and gas produced in Norway. These are not included in either the national or consumption-based account, but are nonetheless important to understand the total embedded footprint of Norway as a nation. Currently, these emissions are estimated to be at least ten times bigger than the total national emissions of Norway, over 500 tonnes CO2e, dwarfing both national and consumption-based accounts[88]!

HOW CAN WE REDUCE THE CONSUMPTION-BASED EMISSIONS?

Normally, climate policy targets the activities causing emissions directly, following the polluter pays principle. CO_2-fees through domestic tariffs, or as part of the EU Emissions Trading System (EU ETS), target the emitter for the tonnes of CO2e emitted. Consumers are only indirectly taxed, as part of the fee carried over in the form of higher prices, depending on the terms of competition.

While this is the best tool for the majority of national climate policy, there is still room for a consumption-based approach. While not necessarily implying blame or responsibility directly to consumers, it does provide a different framing of emissions, and opens up a range of additional alternative solutions. How can we direct policy in order to promote less emission-intensive lifestyles and still cover our needs?

Circular and sustainable consumption: Overall, the wide range of goods and services that contribute to other consumption-based emissions, it will be hard and impractical to address them all on the level of specific policy. It is more relevant to look at solutions that contribute to reducing the overall impact and amount of consumption. Here we can benefit from circular economics, which helps us find ways of changing or reducing our consumption.

SINTEF has done a study calculating the overall climate impact of circular economics in Norway. They find that by implementing circular economic actions, we can deliver 6-10 MtCO2e emission reductions across several main consumption areas.

As seen above, transport makes out the largest consumption-based emission. A more circular-economic approach to transport can provide the greatest opportunity for emission reduction, supported by SINTEF’s estimates. Up to 2 $MtCO_2e$ of transport emissions could be removed through recycling, redesign and car sharing, a significant reduction from a total national transport emissions of 16.2 $MtCO_2e$. This would act as an overall reduction of transport demand and compliment conventional policies for decarbonizing transport like EV-subsidies, infrastructure support and fossil fuel taxes.

Food and drink is a large consumption-based emission source and is related to households' diets and consumption preferences. The emitting activity is largely agricultural production. Hence this is overlapping with the biomass footprint, originating from the production of agricultural products in and outside of Norway. In order to reduce this, it is necessary both with agricultural policy change and developing approaches for less emission intensive production. However, from a consumer perspective, it is important to make informed choices about the footprints from Norwegian's dietary preferences and help guide them towards more sustainable options, like eating seasonally, more fish and more vegetables. From a circular perspective, particularly food waste elimination can provide significant reductions, around 1.5 $MtCO_2e$.

Lastly, energy and housing make out a large emission source for consumers, consisting mainly of energy use for heating and appliances, as well as emissions embedded in construction materials and furniture. From a consumer perspective this footprint is best addressed through energy efficiency measures targeted at businesses and households, which can help reduce the overall need for energy for heating; support for heating pumps, isolation, or rooftop solar. This can reduce up to 26TWh energy demand, as well as produce up to 66TWh[89]. For buildings, there is again a strong connection to the circular economic approach discussed in the material footprint section, as building materials make out the biggest part of construction emissions[90]. SINTEF finds that reduction in material use and use of secondary materials could reduce up to 1.5 $MtCO_2e$[91].

Addressing value chain emissions: It is important to note that 42% of the consumption-based emissions originate outside of Norway, leaving us with fewer options for reducing them. Most imports come from the EU, subject to many of the same CO_2 emissions regulations as Norway. However, the other major share comes from China. Smaller and more significant contributions also come from the US, Africa and Latin America. The embedded emissions are highly dependent on both the individual company, as well as the energy mix in the country of origin. Norwegian importers should be conscious of the embedded carbon from their imports, either that which is directly caused by production or indirectly through for example land-use change.

In the GHG-protocol used for corporate reporting of climate emissions value chain emissions are referred to as Scope 3 emissions, which means that the emissions are not directly attributed to the company that produces a good. However, they are included in a product's value chain or life cycle assessment. Any producer aiming to provide low-carbon products should therefore aim at reducing these emissions the most. In this way, the Norwegian government, as well as corporate entities, are able to use their procurement power to choose and influence producers with aim at reducing emissions.

Scope 3 reporting should also be the norm for all companies, both private and governmentally owned. Science Based Standards initiative (SBTi) provides detailed guidance for creating a scope 3 account and setting a target aligned with the 1.5 degree Celsius target. They also contribute different strategic approaches to influence suppliers in the value chain.

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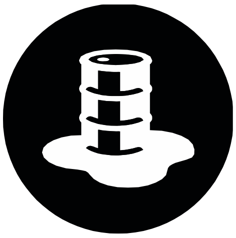
OTHER IMPORTANT NOT YET QUANTIFIABLE FOOTPRINTS OF PRODUCTION AND CONSUMPTION

The six footprints presented so far have enabled us to quantify a per capita planetary limit, as well as Norway's footprint, giving us an estimated reduction target. The footprints either directly relate to one of the nine planetary boundaries, or directly and indirectly affect many of these processes. For example, the material and biomass footprint describe how our production and consumption uses available resources, but the effect of this on the other planetary boundaries are not directly included in these footprints.

We have therefore included other primary drivers and consequences of our production and consumption that pressure the planetary boundaries and cause nature loss, but where we have not been able to quantify the footprint. The described elements are chemical pollution, water pollution, air pollution, water availability and flows, and land-use change and degradation.

For each of these non-quantified footprints, we have attempted to define a proposed target linked to existing conditions, regulations, or international agreements.



CHEMICAL POLLUTION

Target: *Reduce the emissions of all chemical pollutants to levels at or below safe thresholds (preventing emissions where risks are unknown) and restore social and ecological systems damaged by chemical pollution by 2030[v].*

Chemical pollution refers to the release of toxic substances into the environment. These can come in many forms, as many of the products and by-products of economic activities are acutely toxic or potentially toxic under certain conditions. The consequences of these substances entering the environment are equally varied. Pollutants can cause illness and death to humans and wildlife, reduce the ability of ecosystems to perform their essential functions, contaminate soil and water and more.

In 2022, it was announced that the safe planetary boundary for pollutants, including plastics, has been exceeded, based on the first comprehensive assessment published on the planetary boundary called "novel entities"[92]. The scientific community called for policymakers to act to reduce the production and release of pollutants into the environment, including setting a fixed cap on chemical production and promoting a shift to a circular economy.

Researchers highlighted the issue of the increasing plastic pollution in the environment, as well as the many chemicals connected to the release of plastics. In Norway alone, 19,000 tonnes of microplastics leak into nature every year from land-based sources, while estimates from sea-based sources do not exist yet.[93] The most significant contributor to this leakage is car tires, partly from road traffic, and partly from artificial football turfs. Also, this research shows that plastics contain several additives, and some are characterized as persistent micropollutants.

Norwegian politics in this field is highly influenced by EU's sustainable chemical strategy, where they amped up their efforts on a toxic-free environment as global chemical production is expected to double by 2030[94]. The current national strategy for a circular economy highlights the importance of not circulating pollutants, and the will to phase hazardous chemicals out of the economy[95].

[v] As the ecological threshold for each pollutant can vary, the boundary of chemical pollution has been set as 'under allowable levels' as defined by the relevant body. This approach defers to the expertise of science and policy. In addition, it acknowledges that the understanding of a pollutant's harm can evolve over time.

WATER POLLUTION

Target: *Protect, enhance and restore all bodies of water in Norway to achieve 'good ecological status', increase the national Nature Index score from 0.74 to at least 0.85 by 2030, and protect Norway's marine waters from the most harmful pollutants.*[vi]

Water pollution is often represented by a 'grey water' footprint: the volume of water that is polluted within the supply chain, or the volume required to dilute polluted water so that it may be discharged into the environment and meet quality standards. However, the translation of water pollution into an equivalent volume of water necessary for dilution, and vice versa, is difficult to quantify. Consequently, grey water is often excluded from footprint calculations.

Environmental conditions in Norwegian rivers and lakes are generally good compared with those in most other countries in Europe. Nonetheless, assessments show that about one-third of Norway's freshwater bodies do not meet the Water Management Regulations criteria for good ecological status (classed as moderate, poor, bad, or unknown), according to the EU Water Framework Directive[96].

Eutrophication, which relates to nitrogen and phosphorous released into water bodies (see the section on these footprints), is still a problem in many Norwegian rivers and lakes despite the introduction of numerous measures, with little change in recent years[97].

Domestic emissions of hazardous substances have been substantially reduced since the 1980s. However, these substances are found even in the most remote lakes in Norway due to transboundary pollution[98]. Long-range transboundary pollution is a problem, especially in Southwest Norway, and is the leading cause of negative impact on Norwegian water courses. For example, the deposition of airborne mercury originating from other countries is estimated to be twice that of Norwegian emissions in total. Polychlorinated biphenyls (PCBs) cause reduced fertility in birds and mammals. PCBs and newer substances such as brominated flame retardants and perfluorinated compounds have been shown to weaken immune response, disrupt hormones and elevate death risk for the offspring of birds and mammals.

[vi] Because there is no unified indicator for chemical pollution and the boundary of novel entities, a quantitative outcome target based on an overall reduction by 2030 has not been set. Instead, the outcome target for this topic area reflects the need to understand and act to prevent all forms of harmful chemical pollution. C.f. the approach in Metabolic & WWF (2020)., Op cit.

AIR POLLUTION

Target: *Meet and exceed EU Directives on air pollution, while simultaneously assessing and mitigating Norway's contribution to overseas air pollution by 2030[vii].*

Air pollution refers to emissions and atmospheric loading of primary and secondary pollutants of concern. Researchers from the Stockholm Resilience Centre, where the planetary boundary framework was originally formulated, have proposed an 'aerosol loading' boundary, but this threshold is not yet quantified. For this reason, it is not possible to present an outcome target in terms of a single percentage reduction to bring Norway within safe ecological levels of air pollution.

Key regulated air pollutants include nitrogen oxides (NOx), ammonia (NH3), non-methane volatile organic compounds (NMVOCs), sulfur dioxide (SO2) and particulate matter (PM). These pollutants are among the most harmful substances emitted into the air, damaging human and animal health, degrading landscapes, and altering ecosystem functions. Primary pollutants are those emitted directly to the atmosphere, such as SO2 and NOx, whereas secondary pollutants are produced in the atmosphere from precursor gases, e.g., ground-level ozone (O3) and particulate matter (PM2.5 and PM10). Air pollution in Norway is generally low, but as of 2018, Norway failed to meet its ceiling for NOx and NH3, achieving below allowable thresholds for NMVOC, SO2, PM2.5, and PM10[99]. The main sectors responsible for emissions are heavy industry, except for PM2.5, where residential and commercial buildings are the primary source of emissions.

Domestic levels of regulated pollutants are monitored regularly. However, there is no comprehensive data on air pollution that occurs overseas, embodied in Norway's imports. This report does not capture the entire Norwegian footprint connected to air pollution, and we urge others to research this further.

[vii] It is not possible to present an outcome target in terms of a single percentage reduction to bring Norway within safe ecological levels of air pollution. The overall boundary therefore should be taken as 'water pollution under allowable levels for individual pollutants of concern'. As a party to the "Agreement on the European Economic Area" (EEA), Norway must also comply with EU Directives. The current standards are contained in the Clean Air for Europe (CAFE) Directive (EP & CEU, 2008) and the Fourth Daughter Directive (EP & CEU, 2004)[vii]. These Directives also include rules on how Member States should monitor, assess, and manage ambient air quality. Norway has decided to tighten its limit values for particulate matters from 1 January 2016, and thus has stricter limit values than the requirement from the EU Directives.

WATER AVAILABILITY AND FLOWS

Target: *All surface water bodies and at least 90% of groundwater bodies in 'good' or 'high' ecological status by 2030 and Norway supports sustainable water management in key overseas sourcing regions based on quantification of the impact of its imports on overseas water availability and flows.*[viii]

A recent global review of threats to freshwater ecosystems concluded that cumulative changes to water availability and flows are amongst the key drivers of the deepening biodiversity crisis[100]. Water availability and flows relate to the abundance (or scarcity) of freshwater, and the levels of water moving through channels into and out of water bodies are inherently defined according to local context.

Human activities have drastically altered how water makes its way through the environment. Damming, hydroelectric power generation, drinking water treatment, water diversion, irrigation and numerous other activities have reshaped freshwater flows. Only 37% of the world's rivers over 1000km remain free-flowing over their entire length[101]. Extensive water use has also affected its availability: demand for freshwater in some geographies has exceeded the capacity of the water cycle to replenish supplies. The combined effect of these pressures can result in the collapse of habitats, the extinction of species, and the loss of essential ecosystem services that countless people depend on.

Water availability is also affected by changing environmental conditions, like more frequent and intense droughts driven by climate change, and abstraction, or removal and redirection of water for human use, as well as the presence of nutrients (nitrogen and phosphorus).

Management of the ecological status of surface waters is challenging in Norway. In common with most other countries, there are competing demands on surface water and complex cross-sectoral and cross-hierarchical governance structures, and unlike most countries, the hydropower sector is a predominant actor[102].

[viii] 'Sustainable' water availability and flows are inherently defined according to local context.There is a lack of data that makes assessing the overseas impacts of Norway's imports on water availability and flows challenging. It is possible to quantify the 'virtual' water footprint of individual products through Life Cycle Assessments, but there is not a coherent picture of how Norway's demand for goods and commodities is responsible for water scarcity and over abstraction. More granular monitoring of water embedded in supply chains could help Norway minimise its overseas impact on already-stressed freshwater ecosystems.

As part of the European Economic Area, Norway implements the EU Water Framework Directive. According to data from the European Environment Agency, 64% of Norway's bodies were meeting 'good' or 'high' ecological status on the second River Basin Management plan, with 36% classed as moderate, poor, bad, or unknown[103].

Norwegians consumed an average of 180 liters of water per person every day in 2020[104], almost twice as much as the Danes. In Norway, the biggest drivers of water abstraction is the industrial withdrawal (40%), agriculture (31%) and municipal water supply (29% in 2018)[105]. However, this amounts to a tiny fraction of the total renewable water resource[106].

Hydropower is the mainstay of the Norwegian electricity system. At the beginning of 2021, there were 1,681 hydropower plants in Norway, with a combined installed capacity of 33 055 MW. In a normal year, the Norwegian hydropower plants produce 136.4 TWh, which is 90% of Norway’s total power production. Hydropower has significant environmental benefits (low carbon) but can significantly negatively affect water flows, fauna and flora[107].

Water availability is rarely an issue outside of Oslo in Norway, and then only under exceptional circumstances[108]. The response has been to plan for a supply diversification and reduce the current 35% leakage rate[109]. However, low water availability is highly likely to be an issue associated with Norway's imports of goods from places where water-intensive agriculture and industry may be occurring in arid regions. Approximately 70% of the world's freshwater use is related to agriculture and food production[110]. This dilemma is rarely debated in the public scene, and the Norwegian water footprint may be much higher than most Norwegians realize.

LAND-USE CHANGE AND DEGRADATION

Target: *Norway's supply chains of agricultural and forest commodities are responsible for no deforestation or conversion of ecosystems as soon as possible and no later than 2025, degradation of domestic environments is halted, and environmental degradation that occurs overseas as a result of Norway's demand for materials and goods is minimized by 2030.*

Deforestation and conversion of natural ecosystems are responsible for the most severe environmental damages from human land management. Deforestation happens when natural forest is replaced by other land uses, including agriculture or forestry plantations, and when any natural or semi-natural vegetation type is replaced by other land uses[111]. Consequently, deforestation is the subject of the greatest scrutiny from policymakers worldwide, and it drives international dialogue around limiting land-use change. Agricultural, livestock and forest commodities like soy, palm oil, cacao, rubber, maize, beef, leather, timber, and pulp and paper are the main drivers of deforestation and conversion globally[112] [113].

LAND-USE CHANGE FOOTPRINT

The land-use change footprint reflects the quantity of domestic and overseas land that is undergoing conversion or is at risk of conversion due to Norway's demand. The related land-use footprint comprises both the domestic footprint of land under human management in Norway and the embodied footprint of land overseas required to meet Norway's demand for agricultural and forest commodities. Environmental degradation describes the loss of productive capacity and deterioration of key ecosystem features caused by human activities leading to species loss, change in species compositions and reduced ability of ecosystems to provide essential functions[114].

The Stockholm Resilience Centre's 'land-system change' planetary boundary is measured in terms of forested land area as a percent of original forest cover. This is related to the loss of forest cover for agriculture and other human uses, but it is not directly comparable with a national demand-based land-use footprint. While the notion of setting a national sustainable land-use change footprint is not well discussed, the international dialogue around deforestation has reached a clear conclusion: *any deforestation is too much.*

EU's import and consumption of agricultural commodities is responsible for 16% of all tropical deforestation caused by international trade (2017)[115]. It can be translated into 3.5 million hectares of deforestation and associated emissions of 1,807 million tonnes of CO_2.

There is no exhaustive reporting on land-use change in Norway. Thus, it is difficult to determine the extent of it. SSB estimates that 540 km^2 was built down between 2008 and 2019, of which about 42% are forests, 17% agriculture, 20% open solid land, 2% wetlands and 20% already built-up areas[116.] Based on the municipalities' land-use element of their master plans, SSB estimates that 2777 km^2 is planned for further development between 2019 and 2030. Most of this is forest (57%) and open solid land (20%).

Friends of the Earth Norway (Naturvernforbundet) have also analysed which measures cause land changes in Norway117. For direct physical measures, hydropower dams are the most significant cause, covering 1233 km^2. The next drivers are roads and transportation (1131 km^2), buildings (568 km^2), and wind power (14 km^2). When considering changes in nature, including both physical interventions and land change, forestry is by far the largest driver, covering 48421 km^2. Then we find agriculture (11214 km^2), hydropower dams (5930 km^2), buildings (2732 km^2), and roads and transportation (1522 km^2).

We have a better overview of the conversion of forests (to other uses, i.e., land-use change). In Norway, the total forest area has been more or less constant, but when looking closer, we see a decrease in productive forests (economically viable). This can be explained by the size of land either planted or regrown into forest due to abandoned management or climate change, approximately the same as the amount of forest lost to land-use change. The deforestation rate has been approximately 58 km^2 per year since 1990 – 2015, caused mainly by infrastructure (68%) and conversion into pastures and fields[118].

DEGRADATION FOOTPRINT

There are two components of Norway's degradation footprint: (1) direct degradation of domestic environments and (2) degradation that occurs overseas but is embodied in imports of materials (biomass and non-biomass) and goods used to meet Norway's demand.

Degradation is an extremely complex process, largely because a host of environmental impacts could fall under the heading of degradation, and the impacts are not uniform. Consequently, there is no good understanding of Norway's total degradation footprint, particularly degradation linked to production of goods imported to Norway. The major activities contributing to Norway's degradation footprint are forest management (for timber and forest products), agriculture and soil management, mining and quarrying, and leakages of hazardous materials. This footprint is, as you can see, closely linked to other footprints such as material, biomass and different pollution footprints.

REDUCING THE LAND-USE CHANGE AND DEGRADATION FOOTPRINT

A new EU legislation to address deforestation is underway and will also cover the import and export of products to and from Norway. For the law to fully cover the entirety of the footprint of the EU's consumption on our planet's forests and other ecosystems, it needs to not only cover all commodities with a risk of deforestation of tropical forests, but all products contributing to the destruction of forests and other ecosystems, such as grasslands and wetlands. The law must also go way beyond voluntary measures and introduce mandatory requirements for due diligence for both businesses and the finance sector and ensure traceability of commodities and supply chain transparency. In addition to the new EU legislation, it may also be necessary to implement other complementary measures, such as strengthening the cooperation with producing countries to support global efforts to end deforestation, nature destruction, and human rights violations.

To stop conversion of ecosystems and degradation of domestic environments, we must become area and nature neutral, or preferably positive. Area neutrality means that no nature is converted into built-up area. This requires strict management, but is possible to achieve at a local level, for example by the municipalities. Nature neutrality means not to degrade more nature, or to restore nature if degradation is necessary. To become nature positive, we must restore more nature than is degraded. This requires a good overview of the state of the ecosystems and competence to plan and execute restoration projects; thus, it is more difficult to manage at a local level. We propose that the principle of nature neutrality be adopted as national policy and managed on a regional scale.

The first step is to measure the land-use changes by making an area accounting. This accounts for the extent of each ecosystem or area and will tell us the spatial changes of land use over time. However, this will not lead to new knowledge about the status of Norwegian ecosystems as a default. By including an evaluation of the condition to the area accounted for, either using the Ecosystem Condition[119] or Nature Index[120] assessment systems, we get what we call Natural capital accounting. Using this accounting, we may analyse and track changes in the nature index. The UN also includes ecosystem services and ecosystem asset accounts in their System of Environmental Economic Accounting- Ecosystem Accounting (SEEA EA)[121]. The Norwegian Environment Agency and the Norwegian statistical agency is currently working on establishing this for Norway, to further report to Eurostat and other international agencies under the UN.

Managing nature is not limited to efforts to stop degrading it. It is also to restore nature that is already deteriorated. To do this, we need to know which areas and ecosystems need to be restored to achieve a satisfactory state, and the nature capital accounting will provide a good overview of this.

Although restoration of nature is found to pay back as much as ten times the cost of the restoration[122], there is a lack of political will to make this investment. A nature tax has been proposed to prevent more nature from deteriorating and obtain funding for restoration. This fee should be imposed on larger development projects and calculated based on the cost of restoring the same type of ecosystem that is being demolished, including the land price. The fee could be paid to a fund that manages restoration projects in the region. By doing this, it will be more expensive and thus less interesting to develop projects in virgin nature. However, if it’s still done, it will finance nature restoration elsewhere in the region.

THRIVING WITHIN OUR LIMITS, ONE STEP AT A TIME

In order to contribute our fair share to halving the global footprint of production and consumption, and reach an economy within planetary limits, Norway needs to achieve an overall reduction of two thirds of our national footprint from production and consumption.

As we have seen, this does not imply that one footprint can be exchanged for another. We need to take a holistic view, covering all the six major footprints, as well as the secondary ones that were not quantified for this report. In order to reach our targets, we need to take resolute and immediate action: the natural systems that we depend on are today already under pressure from our footprint, we are already way past several of the planetary boundaries and the risk of tipping points that can cause catastrophic collapses is high.

The road towards a nature-positive future and an economy within planetary limits will require paradigmatic changes to bring the global challenges of the nature and climate crisis into clear and concrete terms that enable us to govern and transition.

TO ACHIEVE THIS, WWF HAS IDENTIFIED THREE MACRO-APPROACHES THAT CAN CHANNEL THE DEMAND FOR CHANGE INTO KEY PRODUCTIVE TRANSFORMATIONS[123]:

- **We need to put nature at the heart of governance**. Adjust and complement national planning and governance instruments, so that they effectively and across sectors implement targets and indicators based on a footprint approach to the economy.

- **We need a circular revolution**. The best way to reduce our footprint is through circular economic action that can help us lower overall material consumption and reduce demand for new harmful extraction.

- **We need a food system transformation**. A more sustainable food system can provide our needs through productive and long-term management of agriculturally productive land, better diets, and less use and pollution of nutrients, significantly decreasing our footprint across all indicators.

For each of these transformations, we highlight the actions that **policymakers** and other relevant actors must take. In addition, it is crucial that **the business sector**, which sits at the core of the economic system, also acts to change the way companies operate. Finally, **the finance sector** has an interest, and a responsibility, in facilitating and promoting these changes. We depend on the economy's productive forces to provide us with the products and services that we rely on. They must be mobilized towards reaching the footprint target through better reporting, regulation and cooperation that can provide them with an economic framework for nature positivity.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PUTTING NATURE AT HEART OF GOVERNANCE

To guide our economies towards a safe space for nature and humanity, new indicators and governance tools will have to be implemented[124].

Governments need to think of growth more holistically with the target of maximizing natural capital and well-being alongside economic capital, and steer towards an economy that can function within planetary boundaries. To achieve this, WWF proposes that:

The footprint target and indicator framework is implemented in national governance
New indicators and targets based on our planet's limits will provide a scientific approach to govern a broader range of negative footprints of the economy and should be used to complement current economic indicators.

WWF proposes that the target of “halving the global footprint” is adopted and operationalized with individual quantitative targets according to the “fair share” approach taken in this report, for each of the 6 footprint indicators: Ecological, Material, Biomass, Nitrogen, Phosphorus, Climate. This should be coupled with the other 5 footprint indicators, which are not yet quantified, namely Chemical pollution, water pollution and air pollution, water availability and flows, and land-use change and degradation.

Current pledges by the Norwegian government are limited to ecological footprint. However, given the complexities of the total footprint of our production and consumption, it is clear that the ecological footprint as a single indicator is limited. It needs to be supported by the wider set of indicators in order to measure overall progress and reduction of impacts on natural capital, as well as progress on specific sectors and natural resources.

OUR PLANET MUST SET LIMITS FOR THE NATIONAL BUDGET

Nature, climate and environmental policy has generally not been lacking ambitious targets or goals. However, the implementation is sadly not always put to the fore, and their actual development is patchy. For instance, Norway did not manage to succeed in any of the goals agreed upon in the Aichi agreement[125]. It is vital that the footprint indicators are not simply forgotten or added to a growing pile of indicators and targets, leading to nothing but "reporting fatigue".

In order to make sure that the footprint framework is followed up regularly and with concrete and targeted actions, we propose that they are lifted to the level of national budgeting, as part of the so called "Green book" (Prop. 1 S 2022-2023), which was added by the government as a new governance tool designed to monitor and assess current plans and actions to reach climate objectives. This will elevate nature and the reduction of footprint to the same level as climate policy, prompting a clear formulation of approach and achievement of targets, as well as opening the space for regular debate on the issue.

The nature part of the budget should also cover other aspects of nature related reporting and governance. Currently the government is working to incorporate natural capital accounting in the state budget, following the recent SEEA standard. This provides a good overview of nature types in Norway, their condition and their estimated value contribution to society.

In addition, Norway already has 24 national environmental targets, with a total of 83 indicators in place to track their status. Together they are meant to show the current state of the environment[126]. However, the high number of individual indicators and targets can be overwhelming and hard to integrate into a common and holistic strategy[127].

The footprint indicators here provide a unique and complimentary frame for the other environmental objectives, as they incorporate the planetary boundaries and link the observed impacts to nature in conventional environmental monitoring with concrete human activity that cause the negative impacts. When implementing the footprint framework, it should be more thoroughly assessed how the footprints correlate and contribute to the other environmental objectives and create more targeted and streamlined approaches to governance.

WE NEED A CROSS-DEPARTMENTAL STRATEGY FOR REDUCING FOOTPRINTS

The footprint framework can contribute to better governance strategies as they work on the intersection between economic activity and resource use, such as the material footprint of the economy (UN SDG 12). As we have seen from the footprint analysis in this report, addressing these underlying drivers can often help drive mitigation of a wide range of impacts. It can also allow better coordination and direct a wider set of policy measures, such as governmental ownership, financial planning and budgeting, or sector-specific plans on transport, waste or agriculture, to help achieve the overall nature objectives.

Additionally, the footprint indicators cover Norway's impacts domestically and overseas. This can help us capture important nature and climate-related dimensions related to other policy areas such as foreign aid, trade, climate adaptation, and climate risk in global supply chains.

The government should therefore integrate a new cross-departmental strategy for footprint and the planetary boundaries, to be used by all and across all departments. This should be a central part of a national action plan for more Nature (following CBD). The Ministry of Climate and Environment should take the lead on this and be given a strengthened role to ensure that the footprint framework guides our actions in the green transition, and that all national strategies, action and sector plans include targets on footprint and aligning with our planetary limits.

By elevating the footprint-target to the level of national budget in the "Green Book" it marks an important responsibility for the ministry of finance. They should implement the footprint into their planning instruments, such as the official outlook for the Norwegian economy, as presented by the Ministry of Finance (in Norwegian called "Perspektivmeldingen"), which should include an analysis and action points from the government on how the economy can thrive within planetary boundaries. As well as securing that taxes and fees – and work on these - help us reach the targets.

Important political decisions should be considered on the basis of all the footprint targets.
This entails that we need to include climate, nature and the footprint framework as part of the Instruction for official studies, (in Norwegian: Utredningsinstruksen)[128], which is currently used

for evaluating the wider impact of state decisions. This instruction applies to all action, reforms, changes in regulations and investments taken at state level. Currently, it lacks specific requirements and guidance on both climate and nature, which currently forms a huge gap in how decisions are made on state level [129].

WE NEED BETTER DATA AND STATISTICS

This report has been made possible from publicly reported data and has as such benefitted from the statistics published by Statistics Norway (SSB). The footprint indicators are not new to either the Norwegian Environment Agency or Statistics Norway. But they are currently not reported on directly, but rather compiled by third-parties such as Eurostat or the Footprint network into other statistical indicators.

Statistics Norway should therefore be tasked with compiling and reporting the full footprint indicators and the underlying data.

This would for instance require reporting on consumption-based climate account similar to the one used in this report, where the embedded emissions of exports and imports are accounted for. Similarly additional reporting is needed for the material flow accounts. In order to provide a full account of the "consumption and production" it is necessary to calculate the embedded material footprint of imports and exports. This is made possible through own models for input-output modelling.

The underlying data would also have to be reviewed for gaps and completed, as many of the reporting requirements from Eurostat are voluntary, they are omitted. One example is the domestic production of meat[130], as explained in the footprint deep-dives.

Overall, there should be close coordination between the political objectives on nature and climate and the reporting of Statistics Norway, which should be used actively in decision making. There has previously been lack of coordination between government and work on the SDGs in Statistics Norway, which has also been pointed out by the Auditor General of Norway[131]. A holistic implementation strategy of the footprint goals should therefore be coupled with good and reliable data.

A CIRCULAR REVOLUTION

A key barrier to reducing our footprint in a significant way is that most of our current production and consumption is based on a linear "take-make-dispose" model, where resources are extracted from nature and transformed into products that quickly become waste. To break the cycle, we cannot rely on technology alone*; "consumption and production patterns will need to be fundamentally restructured, as well as current* measures *of success"*[132]. Even with further advancement in efficiency, there are no indications that we can keep producing and consuming more and simultaneously reduce our overall resource consumption[133]. This implies a radical move from linear to circular material flows[134].

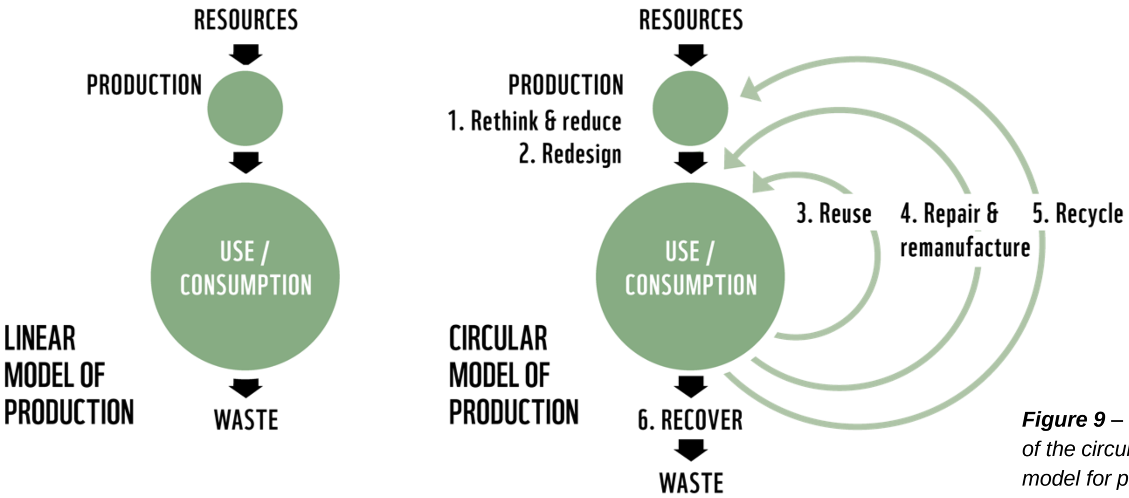


***Figure 9** – Illustration of the circular economy model for plastics.*

***WWF defines** a sustainable Circular Economy as a regenerative system, driven by renewable energy that replaces the current linear ‘take-make-dispose’ industrial model. Materials are instead maintained in the economy, resources are shared, while waste and negative impacts are designed out. A sustainable Circular Economy creates positive environmental and society-wide benefits and functions within planetary boundaries, supported by an alternative growth and consumption narrative. (Figure 9).*

The circular economy narrative has become well-known in Norwegian policy and business context, with many touting its importance. However, this has not translated into any major positive nature impact or reduction in material or other footprints, as small efficiency gains have largely been outpaced by overall increased production, leaving natural footprints bigger than before. In fact, an internal review of Norwegian fulfillment of the UN SDGs carried out by the Norwegian government found that UN SDG 12 was the weakest result for Norway due to the immense footprint[135].

Much of this can be attributed to the lack of clear objective targets for the circular economy that can direct action toward gaining meaningful results. The circular economy is complex and cross-sectional. It encompasses most sectors of the economy, from raw material extraction at the start of the value chain to the disposal of the product at the other end of its life cycle, which means that this shift is a revolution that requires political will and direction at top level.

In 2021, Norway’s first national strategy for the circular economy was launched by the Solberg-government[136]. The government wanted Norway to be a “front-runner” into the circular economy and set up work across all ministries affected, under the coordination of the Ministry of Climate and Environment. The strategy provided an outline for a circular economy in Norway but presented little in terms of concrete actions and tools to bring it about. Neither was it very clear on its overall objectives, mainly pointing to the EU targets as suitable indicators.

This makes it hard to justify more effective policy actions, such as environmental fees or direct regulations, or to direct public funds towards particular circular projects. While circular economy measures have been found by SINTEF to be able to reduce 5 Gt CO_2e from national and imported emissions in Norway, these are largely ignored as part of the traditional climate policy tool case and solution matrix.

The current government has announced plans to build on the existing strategy and launch an action plan for the circular economy that is supposed to contain concrete milestones, actions and policy measures[137]. In order for this plan to be ambitious and properly address the footprint from production and consumption, WWF argues that it must:

ESTABLISH CLEAR TARGETS, INDICATORS AND MILESTONES FOR A 50% REDUCTION IN PRIMARY RESOURCES

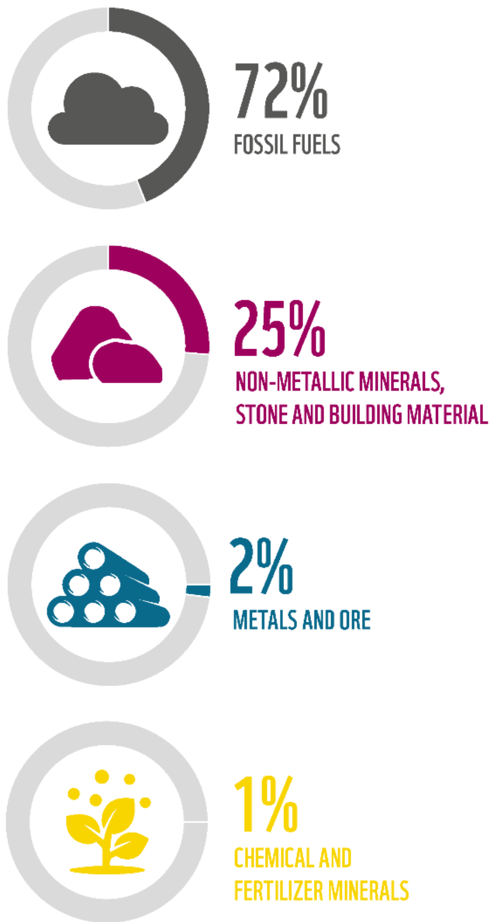
WWF recommends that we use this opportunity to establish clear indicators, targets and milestones for halving the footprint through the circular economy. The circular economy is not an end in itself, but rather a tool to help us reduce the pressure we put on our natural systems and build an economy that functions within planetary limits. In order to mobilize and direct action towards this, the objective of halving the footprint should be guiding the work on circular economy. The footprint framework should also here be used as an indicator framework for a circular economy.

For the circular economy, our material footprint is of most interest, as it sums up the use of materials, minerals, fossil fuels and biomass. Norway is a highly material-intense economy with a correspondingly enormous footprint on nature, as shown in this report. A particular focus should be on the material footprint, where Norway should adopt a target of reducing primary resources (minerals, metals and fossil fuels) by at least 50% by 2030. In order to contribute to the overall goal of reducing the material footprint by 75%, as shown in this report.

As has also been done in the Netherlands, their first goal of the government-wide program is to use 50% fewer primacy resources (minerals, metals and fossil fuels) by 2030[138]. Taking into consideration that Netherland is an *actual* “front-runner” in the circular economy – reporting to Eurostat shows that they have the lowest material footprint in the EU[139], and the economy is already 24.5% circular according to Circle Economy[140] – this target is very ambitious, but most definitely attainable. For a material-intensive economy like Norway’s, such a target can easily be adopted and steer the actions needed towards achieving this goal in the new action plan. Clear national goals and indicators should be coupled with a broad range of measures and actions taken at state and municipal levels.

For the new action plan to have concrete meaning in Norway, the government should present it to the parliament (in Norwegian, “stortingsmelding”). Which includes targeted policies, strong incentives for the industry, and concrete sector plans.

Norway’s consumption of materials per source



CREATE TARGETED POLICIES THAT CONTRIBUTE TO REDUCING OUR FOOTPRINT

Anchoring this at the top level will be crucial, as it will provide a basis for directing more targeted policies to solve environmental objectives. A new market for circular materials, products and services will need to be made. Here policy makers can use taxes, product standards, requirements on product lifetime, public procurement, a ban on the practice of planned obsolescence, and new programs under Enova and Innovation Norway to fast-track the shift needed. Secondly, more and better extended producer responsibility schemes, return schemes and other financial incentives to close the loop and reduce waste is needed (i.e., on textiles as discussed above under biomass). This should be seen in close relation to requirements and targets for waste management, to stop leakage from the system.

Lastly, new platforms and technological solutions are needed, including material flow analysis and material banks to be used across sectors to help create synergies. New circular ways of doing things should be secured by implementing strong incentives for doing so. This could be done by new circular criteria and/or fees, or it can also be done by including circular principles and reduction of our material footprint as a part of the mandate for Enova, as well as the potential “biological cousin”, Bionova” which will target activities in bio-based sectors such as agriculture, aquaculture or forestry. In that way, we can make sure that solutions with a proven effect on our needed footprint reduction - which are not yet profitable due to our linear economy – can be trialled and hopefully scaled.

PRIORITIZE FOR CRITICAL AND HIGH-IMPACT SECTORS

Action should be directed towards the material flows that has the most potential benefit for nature, and the sectors affected should have circular economy as an integrated part of relevant governmental plans. Implementing a set of circular economy interventions in four sectors with large impacts on nature, namely food, aqua- and agriculture, construction, textiles and forest, can halt global biodiversity loss even if no other action is taken, and make the world's biodiversity recover to the same levels as in the year 2000 by 2035, as found by the Finnish agency SITRA[141].

However, in Norway most existing sector plans lack a circular focus and are still based on a linear growth narrative, as they mostly depend on increased resource use to achieve growth or access to resources. An example is the plan for forestry in Norway. Here increased activity is assumed to continue, which will inevitably lead to less natural carbon storage in Norwegian forests. A sector plan based on circular principles could, on the other hand, secure natural carbon storage and reduced emissions.

Again, we can look to our neighbors in the Netherlands, who already in 2018 launched plans for five specific sectors, namely Plastics, Consumer Goods, Manufacturing, Construction, Biomass and Food[142]. Similarly, Norway should adopt a sectoral approach and conduct an analysis that maps the potential for material footprint reduction across sectors in Norway.

While the material flows are important, they in themselves tell a limited story, as they are measured in tonnes of various materials equally without differentiating for particular environmental consequences. The rest of the footprint- indicators and other negative associated impacts must also be considered in a life cycle perspective. As with plastics, while not the biggest material flow measured in tonnes, it still has a range of associated impacts, such as water pollution, harmful chemicals, carbon emissions from burning and producing, detrimental impact on biodiversity when lost in nature, and an unknown, but likely increasing, impact on our human health.

Another example highlighted in this report is critical minerals, which will be necessary for the green transition. Currently, the discussed solutions are centered around new extraction, either on land or even in vulnerable deep seabed deposits. However, the most sustainable approach would be circular: mapping the existing and future minerals in the economy, recycling and reuse, as well as demand reduction through either sharing and collective solutions, as well as responsible innovation to find alternatives or less mineral use.

Lastly, SITRA showed that the sector where circular interventions can have the greatest positive impact is food and agriculture at a global level[143]. Merely by shifting to more alternative proteins (less meat, more plants) and regenerative agriculture, and by reducing food waste by half, biodiversity loss could be halted by 2035 by freeing up agricultural land corresponding to as much as 1.5 times the size of the entire European Union, which we delve on under the "Food systems transformation".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FOOD SYSTEMS TRANSFORMATION

Of all our footprints, how we produce and consume food is the single biggest driver of biodiversity loss, deforestation, water scarcity and pollution, land degradation, and pesticides toxicity. It also has a significant contribution to climate change. This is primarily due to its massive use of land: over half of the planet's habitable land is used for food production, and most of this (82%) is devoted to producing animal food through grazing and feed production. Unsustainable forestry and overfishing are causing overexploitation of available resources.

In addition, the global production and consumption of food is causing social problems and health issues. It is a major driver of the emergence of infectious diseases. Unhealthy diets are the biggest cause of non-communicable diseases, and 1.9 billion people are obese or overweight. At the same time, uneven distribution and access to nutritious food causes nearly 700 million people to go hungry every day, while we waste one-third of all the food produced, which includes the natural resources that went into its production[144].

Given the projected increase in global population and the demand for resource-intensive food, we will not succeed in reversing the degradation of our planet and bend the curve of nature loss, without a radical transformation of our food systems. In fact, in a scenario where the entire world adopted the same dietary patterns as in the G20 countries, the planetary limit for food-related GHG emissions would be exceeded by 263% and require up to seven Earths to support food consumption.[145]

The Norwegian food production system is estimated to be quite robust, but still at risk. A recent study[146] found that climate change will make it more difficult to produce food both on land and in the sea, and it will also influence Norway because we import a lot of food and animal feed. As suggested in our report, a transition to a lower-footprint food system would therefore also serve Norway's interest in becoming more resilient to environmental risks and geopolitical aspects linked to the price of imported materials.

WWF has outlined risks and solutions for the food sector in several major reports[ix], concluding that food consumption and production need to be transformed across three main areas:

- **Production: A shift to sustainable agricultural practices based on agroecology**
- **Demand: A shift to plant-based diets**
- **Elimination of food waste**

These transformations are widely supported by a number of research and international organizations[147], including the International Resource Panel. Estimates show that the investment necessary to transform food systems would lead to 15 times more value in terms of avoided negative costs, creating benefits for the economy, society and the planet[148] [149]. Following the same concepts as we use in this report, the EAT-Lancet report[150] has defined what a healthy and sustainable diet within planetary boundaries looks like.

SHIFT TO SUSTAINABLE AGRICULTURAL PRACTICES BASED ON AGROECOLOGY

The conventional approach to farming is based on heavy tillage, soil left bare, monocultures and the systematic use of chemicals and fertilizers, which leads to a depletion of soil fertility and leaves no space for biodiversity to co-exist and thrive alongside growing crops. Agroecology is a widely supported alternative that can reverse the negative trends and increase soil fertility, store atmospheric carbon and benefit biodiversity, while decreasing pressure to open up new land for cultivation as monoculture soils become depleted. Agroecology also includes social considerations of sustainable livelihoods, fair working conditions on the farm, and resilience of rural communities. When it comes to farming practices specifically, WWF highlights four key principles that define an environmentally sustainable on-farm agricultural production: (i) Minimise soil disturbance, (ii) Permanent soil cover, (iii) Increase plant and species diversity, (iv) nutrient cycling and circularity[x].

These can be implemented across all geographies, and adapted to the local context. Norway has a less intensive and extensive agriculture than most developed countries, but it is nonetheless often based on the very same practices that, over the long run, will deplete the soil and require constant external inputs such as chemicals and fertilizers. Therefore, Norway should shift to sustainable agricultural practices based on agroecology and ensure that sector plans are updated accordingly.

[ix] Support ranges from UN-led agencies such as FAO, IPBES, IPCC, to research teams in leading universities, institutions such as the European Environmental Agency, and many more. A complete description of the three transformations can be found in WWF (2021). *Bringing it down to Earth: Nature risks and agriculture*. WWF-Norway and WWF-UK. https://wwf.panda.org/wwf_news/?2660466/nature-finance-risk-and-agriculture

[x] For a more complete discussion of agroecology, the broad support for it, as well as a description of the four principles and tools available for businesses and finance, refer to WWF (2021). *Bringing it down to Earth: Nature risks and agriculture*. WWF-Norway and WWF-UK. https://wwf.panda.org/wwf_news/?2660466/nature-finance-risk-and-agriculture

SHIFT TO PLANET-BASED DIETS

Plant-based food sources, like vegetables, legumes, cereals and nuts, generally have a much lower planetary footprint than animal-based products. The production of animal feed and areas needed for pastures use up most of the food production areas in the world. Even a modest reduction in consumption would imply a significant reduction in environmental impact.

In general, a simple explanation for why animal foods have a higher impact on nature is that eating e.g. cereals and beans directly instead of feeding them to animals is an inherently more effective way to feed the human population, as it does not waste food in the conversion to animal food. As an example, for every 100 kilocalories and 100 grams of proteins you feed a cow, you only get two kilocalories and four grams of proteins back as beef. The most efficient animal foods, such as eggs and milk, reach a mere 24 kilocalories and 25 grams proteins[151]. This means that the same amount of cropland can feed many more people that eat plants directly instead of feeding them to animals. Despite this, an estimated 33-39% of all edible crops in the world are today used to raise livestock in intensive factory farming rather than for direct human consumption[xi]. Less than half of the world's cereals are eaten by humans, with the rest used for animal feed and biofuels. Only 7% of all soybeans go towards human foods such as tofu, tempeh, and soy milk.

WWF's *Bending the Curve: The Restorative Power of Planet-Based Diets*[152] analysed the dietary patterns of 147 countries, including Norway, and estimated how impacts would change when adopting different diets. The overall conclusions were that some countries might need to increase consumption of certain foods, including dairy, fish, fruits and vegetables, to fight undernutrition. In contrast, rich countries need to decrease meat and dairy consumption. For Norway, reducing the consumption of meat, especially red meat and dairy products, to levels in line with the official national dietary guidelines would reduce food related GHG emissions by 14%, and up to a reduction of 85% following a vegan diet (see figure 9 on the next page). Reducing food waste and dietary changes is one of the most effective ways to reduce greenhouse gas emissions in Norway (for those sectors not subject to carbon quota)[153]. This includes less red meat and more plant-based food and fish, which follows current dietary guidelines from the authorities.

[xi] Of all the calories produced by the world's crops, only 55% are eaten directly by people, 9% are used for biofuels and other industrial uses, and 36% are being used for animal feed. Of those feed calories, only 12% are ultimately eaten by humans as meat and other animal food. Cassidy, E. S., West, P. C., Gerber, J. S., & Foley, J. A. (2013). *Redefining agricultural yields: From tonnes to people nourished per hectare*. Environmental Research Letters, 8(3), 034015.

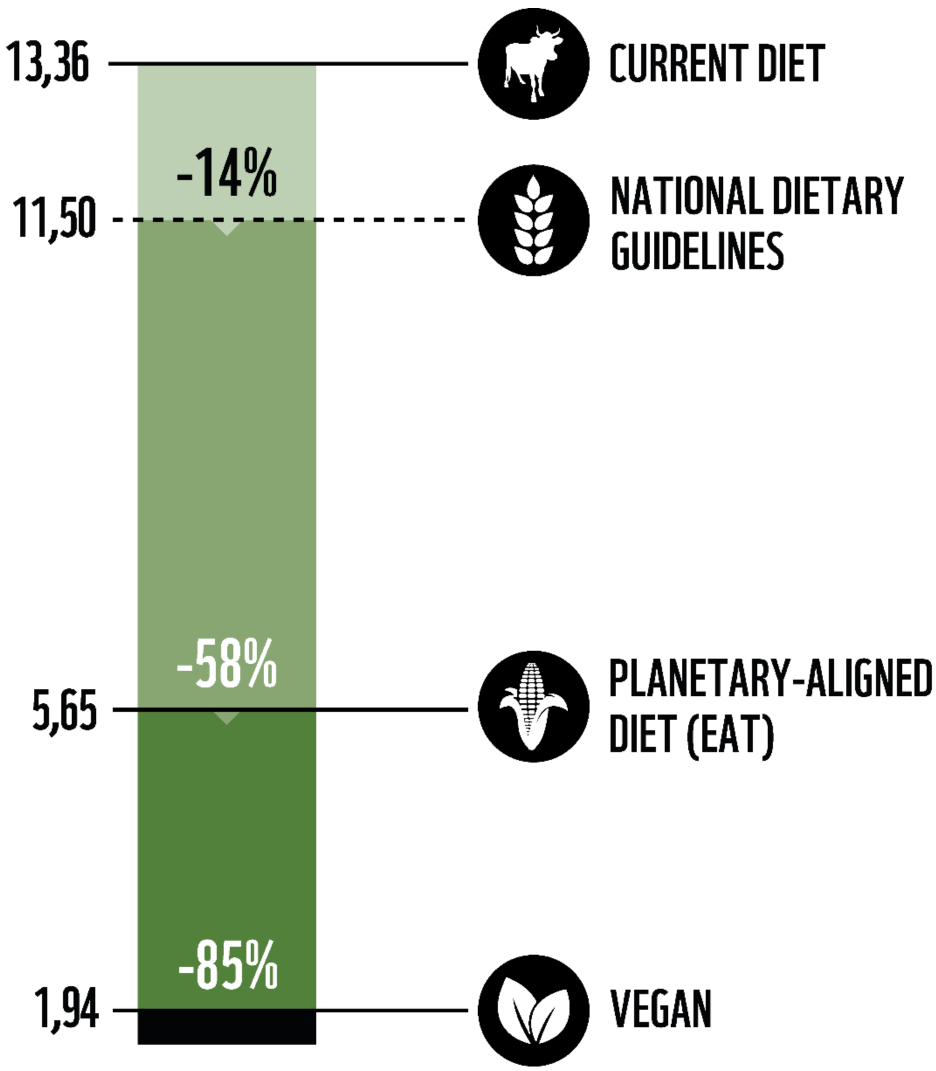


Figure 10: *On the left axis, GHG emissions per capita associated with each diet, in MtCO2e. On the green column, reduction in GHG emissions with different diets, compared to current diet. Data from WWF (2020). Bending the Curve: The Restorative Power of Planet-Based Diets. WWF Report.*

The same dietary changes, to be in line with national nutritional guidelines or a vegan diet, would respectively reduce eutrophication with 8% and 65%, water use from no change to a reduction of 45%, arable land use with 6% and 42% and pastureland with 36% and 100% (since a vegan diet does not require any grazing land). Despite the huge land area saved, the model shows that impacts on biodiversity loss would only be reduced by 1% to 5%, but this is mainly because the land which is no longer required for food production is not estimated to be restored back natural ecosystems. Another explanation is that about half of the biodiversity impacts in Norway is linked to consumption of coffee, tea, cocoa and spices from tropical regions, which is set to stay the same across all diets.

In line with this, Norsk Klimastiftelse[154] estimated that adopting a “flexitarian diet” which halves the consumption of meat in Norway would lead to a 30% reduction in demand for soybeans,

between 30 and 40% reduction in emissions, about 25% reduction in demand for nitrogen fertilizers and about 30% reduction in land use.
WWF therefore emphasizes the importance of eating less and better animal foods from sustainable production systems, based on, for example, a “livestock on leftovers” approach, which limits animal protein consumption to what can be produced by raising animals on available grazing lands, by-products of agricultural crop production and food waste. In practice, this would rule out most of the animal food produced today in industrial farming and naturally rebalance prices, consumption and production to more sustainable levels. The same principles of conversion efficiency are true for Norwegian livestock, so this means that Norway should use its available grazing land, where it is not possible to grow crops for direct human consumption and reduce the production of animal food dependent on edible crops such as soy and cereals, while increasing the variety and production of locally grown edible crops.

Norwegian dietary patterns should progressively align with a scenario in which Norway makes the best and most resource-efficiency use of the available resources, thus reducing its footprint and moving towards planetary alignment. WWF recommends Norway to update national guidelines to be in line with planetary boundaries and consider to set targets to specifically reduce impact on biodiversity.

ELIMINATION OF FOOD WASTE

To eliminate food waste is a priority, as a third of all land, together with freshwater, machineries and fossil fuels, chemicals and fertilizers, is used to produce food that will go to waste and never be consumed. This is caused by a combination of systemic challenges all along the value chain, such as bad farming practices, consumer behavior, and an increasing centralization of production which exerts a downward pressure on prices. This can in turn hinder farmers’ ability to invest in necessary equipment to reduce food waste and, in extreme cases, crops are left to rot in the field because harvesting costs are not covered by sales revenues. Consumers, food producers and companies, politicians, and financial institutions, have a responsibility to securing farmers’ incomes and reducing food waste.

Norway has an existing commitment agreed between the food sector and the government to reduce post-harvest food waste by 15% by 2020, 30% by 2025 and 59% by 2030[155], a reduction of 12% is achieved between 2015-19[156]. To be able to reduce this footprint, Norway would need to reduce post-farmgate food waste by at least 50% by 2030 from a 2015 baseline. Norway should make sure to reach our targets, which some argues can be done by a new law regulating food waste, as described in the deep dive of Norway’s biomass footprint.

MOBILIZE BUSINESS AND FINANCE FOR NATURE

It is worrying that there are no established ways for reporting and assessing how companies are impacting nature or performing when transitioning to a circular economy, nor any concrete formulation of how this can help us thrive within planetary limits and reduce pressure on nature. It has, for example, been shown that among Fortune 500 businesses, many disclose sustainability indicators, such as emissions. But few, if any, report on how their business model affects nature and other important planetary boundaries, such as nutrient use, biodiversity impacts, or even material footprints[157].

Consequently, the finance sector is similarly lacking good metrics. Low quality reporting leaves them in the dark on how companies are operating regarding nature, exposing them to the risk of loss as these business practices might permanently deteriorate the natural systems they depend on. This part of the report therefore includes recommendations to businesses and finally the finance sector.

RECOMMENDATIONS TO BUSINESSES

Reducing the footprint by two-thirds requires that most companies redefine their business model radically. Many companies indeed claim that they work to become circular, but, at the same time, few, if any, systematically measure their circularity and can prove actual progress, let alone any reduction on their impacts.

Businesses must start measuring their footprint(s) on nature and their circularity performance. Without this step, any commitment remains unproven, and we are not able to track how they contribute. These indicators must become an integral part of how companies are valued and measure their success.

How can this be done? In 2001, researchers at the Stockholm Environment Institute[158] developed and tested an "Ecological Footprint accounting tool", which businesses can use to measure all their impacts on nature and aggregate them into one overall footprint metric. Fast-forward to today, and several tools are available to measure businesses' circularity performance[159]. The most used tools are the *Circular Transition Indicators Tool* (CTI) by the World Business Council for Sustainable Development (WBCSD), and *Circulytics* by the Ellen MacArthur Foundation. However, one challenge is that it is hard to compare the degree of circularity across the different indicators and tools[160]. The second challenge is that, despite the availability of tools, circularity still does not constitute a systematic part of companies' reporting and is not yet considered as a steering indicator. Businesses have or will soon also have access to tools such as Science Based Target for Nature (SBT-N) which allows them to set science-based targets linked to different aspects of nature. When assessing nature-related risks, the Taskforce on Nature-related Financial Disclosures (TNFD) will set a global standard reporting framework, while tools such as WWF's water and Biodiversity risk filter will allow companies to assess location-specific risks.

Measuring things such as circularity and material consumption would not be much different from what businesses do today on the climate side. The world agreed to reduce the climate footprint to limit global warming to 1.5 degrees Celsius, and companies have started to measure, set targets and systematically report on their emissions. This information is increasingly being used by other players such as financial institutions to reward or downgrade companies based on their climate commitments and results. Halving the footprint is a broader goal which also includes climate, and the footprint framework presented in this report provides a set of indicators acting in this the same way as the 1.5 degrees Celsius scenario does for climate.

Many pioneering examples show that it is possible to rethink business models which can produce wealth for the company and society in different ways. Transitioning from a linear to a circular economy will likely mean radical transformations, or even disruption, for many current business models. But this does not have to mean doom and gloom. On the contrary, we believe that the imperative to change will unleash market forces and spur the innovation and creativity necessary to find innovative ways to transition business models while keeping profitability and market share. We need growth in creative solutions that can keep our current high standard of living while reducing our material footprint.

As we argue in this report, measuring is the first necessary step to reducing footprints. But when measuring is in place, the second step is to tie these measurements to new sets of incentives. In other words, companies' efforts should be visible and rewarded by policymakers and the market. For example, subsidies and taxes should facilitate companies that are able to demonstrate progress toward a higher circularity and lower demand for natural resources. The market, in its large definition, can also create powerful incentives for companies. Consumers can be empowered to recognize circular products with lower footprints. But a strong, necessary incentive must come from a key player of the market, the finance sector.

RECOMMENDATIONS TO THE FINANCE SECTOR

The finance sector is, together with policymakers, the strongest lever for businesses to change. Financial institutions – banks, insurers and investors – must provide companies with the necessary incentives to start a circular transformation and re-design the way they use nature. This should not be considered an additional element to the current work on climate, but as a central part of the ongoing work to consider nature and nature-related risks. The finance sector should:

Integrate circularity as an instrumental tool to manage and reduce nature-related risks. Finance should consider companies' ability to become more circular and reduce their dependency on new natural resources as a key indicator of reduced nature-related risks for the business. This should be an element of the current work which is being done to understand how companies in a portfolio impact on, and depend upon, nature. The UNPRI recently supported[161] this view, asking financial institutions to support the transition to a circular economy to mitigate the physical, transition and systemic risks associated with a linear economy, including climate change and nature and biodiversity loss. One of the first-of-its-kind analysis[162] showed that companies with a higher circularity can de-risk investments and drive superior risk-adjusted returns. This supports our argument that pushing companies to become more circular can be a leading way to reduce companies' impacts on biodiversity and, at the same time, their exposure to potential nature-related risks. This can provide an effective complementation to current approaches to assess and manage nature-related risks (see further explanation in the box).

FOCUS ON MATERIAL USE AS PROXY FOR BIODIVERSITY IMPACTS

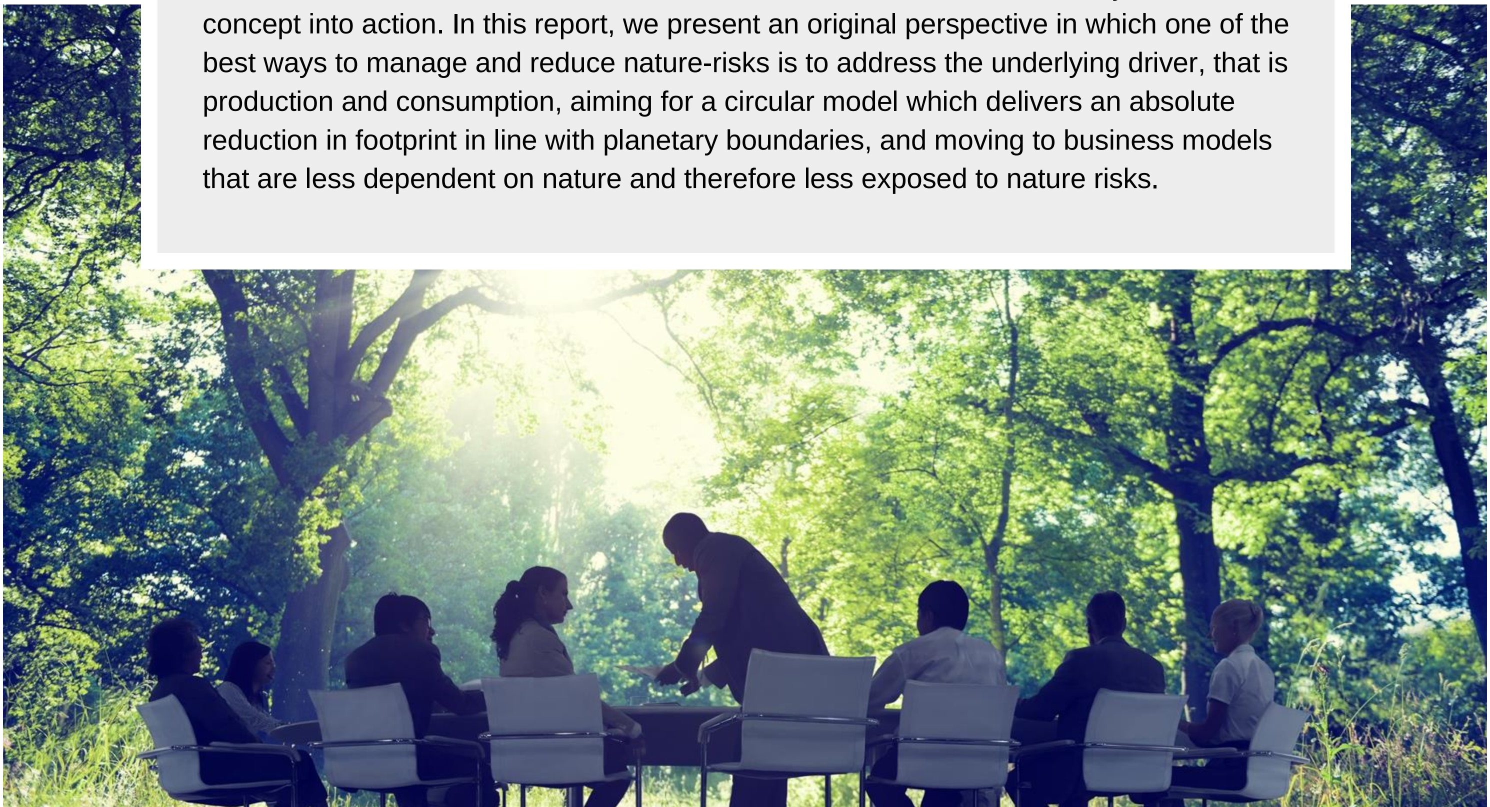
Measuring nature-related risks for businesses and finance, and reducing impacts on nature, is a growing concern. Currently, the main approach to this complex problem is to try to estimate how companies, and related financial investments, impact nature and are dependent on nature, by using detailed data such as locations and looking at how these interact with biodiversity-rich areas, water-stressed areas, etc. This is a valid and potentially very accurate way to map out companies' dependencies and risks. However, it is fairly complex and will not necessarily create strong enough incentives for companies to reduce their footprints by transitioning to circular business models. In this report, we propose a complementary approach in which we focus on companies' direct responsibility for the loss of nature and biodiversity through their demand for primary resources, which, as described in the introduction, is the leading cause of biodiversity loss. By focusing on companies' own measurable footprint, it is possible to set targets and measure the transition towards a circular economy by reducing the demand for new, primary materials.

Develop innovative financial products linked to circularity, to support companies' ambitions and plans to transition. E.g., banks can provide circularity-linked loans and bonds to offer better financing to transformational projects, while the insurance sector can offer lower premiums for circular solutions. The latter has a strong Interest in repairing and reusing materials whenever possible, to keep the costs low.

Integrate circularity-elements from current and upcoming regulations, such as EU-Taxonomy, Corporate Sustainability Reporting Directive (CSRD), and Sustainable Finance Disclosure Regulation (SFDR). Most upcoming regulations include circular economy as a key focus with indicators that companies will need to report on. Finance should consider using these and integrate them in their analytical tools and strategies while demanding data providers to include more indicators on circular economy and footprints.

NATURE-RELATED RISKS = LINEAR RISKS?

The degradation of our planet can affect businesses', and society at large's, ability to function and prosper. In fact, almost all human activities are dependent on functioning nature and ecosystems, and when these gets degraded, potential "nature-related risks" emerge. These risks arise not only from physical degradation of ecosystems, but also from changes in regulations, market preferences, etc., and go hand-in-hand with the well-known "climate-related risks". Both type of risks can be considered as consequences of what some call "linear risks", that is our economy's dependency on the use of non-renewable and virgin resources, and a general failure to embrace a real circular model[163]. Increasingly, countries, businesses and financial institutions are trying to understand and measure these risks, but little has been done to actually turn this concept into action. In this report, we present an original perspective in which one of the best ways to manage and reduce nature-risks is to address the underlying driver, that is production and consumption, aiming for a circular model which delivers an absolute reduction in footprint in line with planetary boundaries, and moving to business models that are less dependent on nature and therefore less exposed to nature risks.



GLOSSARY

Term	Explanation
Acidification	A reduction in the pH of water bodies (including oceans) over time. Ocean acidification is primarily caused by uptake of carbon dioxide (CO2) from the atmosphere. Acidification of freshwater is primarily caused by sulphur oxides (SOx) and nitrogen oxides (NOx) entering the water from atmospheric depositions and soil leaching.
Air pollution	Air pollution consists of any chemicals or particles, both physical and biological, in the air that can harm the health of humans, animals, and plants. It also damages buildings.
Anoxic event	A situation where parts of the ocean are deprived of oxygen and become acidic to the point of toxicity
Agroecology	Agroecology is widely supported among international and research institutions as an integrated approach that applies ecological and social principles to the design and management of sustainable agriculture and food systems. When focusing on the practical application to farming, it can be defined as a set of practices, based on traditional and regenerative approaches, that mimic natural processes and enhance beneficial biological interactions and synergies on the farm. Such practices focus on improving soil heath, boosting fertility and organic content, and increasing biodiversity. Four core principles of agroecology are i) minimising soil disturbance and tillage, ii) maintaining an ‘armour’ of plant residues and cover crops over the soil rather than leaving it bare, iii) fostering plant diversity, and iv) ensuring nutrient cycling and circularity.
Biocapacity	The capacity of ecosystems to regenerate what people demand from those surfaces. Life, including human life, competes for space. The biocapacity of a particular surface represents its ability to regenerate what people demand.

Biomass footprint	Biomass consumption relates to the consumption of agricultural products, animal products, forestry products and fishery products. In footprinting, the biomass consumption footprint is the proportion of global production or extraction of biomass materials which is attributable to the domestic demand of a country. It is a sub-set of the broader Material Footprint which comprises biomass, fossil fuels, metal ores and non-metal ores.
Chemical pollution	Chemical pollution refers to the release of toxic substances to the environment. Chemical pollution can come in many forms, as many of the products and by-products of economic activities are acutely toxic or have the potential to become toxic under certain conditions. The consequences of these substances entering the environment are equally varied. Pollutants can cause illness and death to humans and wildlife, reduce the ability of ecosystems to perform their essential functions, contaminate soil and water and more.
Degradation	Degradation here refers to land degradation, which is the reduction or loss of the biological or economic productivity and complexity of rain—fed cropland, irrigated cropland, or range, pasture, forest or woodlands resulting from natural processes, land uses or other human activities and habitation patterns such as land contamination, soil erosion and the destruction of the vegetation cover.
Ecological footprint	The impact of human activities measured in terms of the area of biologically productive land and water required to produce the goods consumed and to assimilate the wastes generated. Measured in ‘global hectares’.
Ecosystem condition	The state (or ‘health’) of ecosystems, which includes their physical, chemical, and biological characteristics and the processes and interactions that connect them. “Ecosystem Condition” is also an assessment tool used to evaluate the conditions of different ecosystems in Norway, using a combination of two different assessment methods, “Panel-based assessment of ecosystem condition (PAEC)” and “The index-based ecological condition assessment (IBECA)”. It is a tool developed for the Norwegian Environmental Agency.

Eutrophication	Eutrophication is the excessive enrichment of waters or other ecosystems by nutrients such as nitrogen. The two most acute symptoms are hypoxia (or oxygen depletion) and harmful algal blooms, which among other things can destroy aquatic life in affected areas. The rise of eutrophication is attributed to the increase in intensive agricultural practices, industrial activities, and population growth which together have increased nitrogen and phosphorus flows in the environment.
Footprint	the global footprint of production and consumption refers to the impacts of extraction, production, consumption and related socioeconomic activities on nature, as well as the drivers and pressures that cause this impact
Greenhouse gases	The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N20). Less prevalent -but very powerful - greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).
Material footprint	Material Footprint is the attribution of global material extraction to domestic final demand of a country. The total material footprint is the sum of the material footprint for biomass, fossil fuels, metal ores and non-metal ores. For the purpose of this report, biomass (a separate driver and usually port of the material footprint) has been removed from all quantifications where possible.
Natural Capital accounting	Natural Capital accounting is a tool to measure the changes in the stock of natural capital at a variety of scales and to integrate the value of ecosystem services into accounting and reporting systems at international, Union and national level.
Nature index	Nature Index is a tool used to assess the condition of the biodiversity in Norway. It gives an overview of the development of certain ecosystems, species groups and themes. It is a tool developed for the Norwegian Environmental Agency.
Nitrogen footprint	Relates to the use of nitrogen as a nutrient input in agriculture. These nutrients are added in mineral (industrial fertilizers) and organic (e.g., manure) forms.

Novel entities	The novel entities boundary, formerly known as “chemical pollution” in the planetary boundaries framework, refers to entities that are novel in a geological sense and that could have large-scale impacts that threaten the integrity of Earth system processes. These are “new substances, new forms of existing substances and modified life forms”, including “chemicals and other new types of engineered materials or organisms not previously known to the Earth system as well as naturally occurring elements (for example, heavy metals) mobilized by anthropogenic activities”. The introduction of these entities is of concern when these entities exhibit persistence and accumulate in organisms and the environment.
Phosphorus footprint	Relates to the use of phosphorus as nutrient input in agriculture. These nutrients are added in mineral (industrial fertilizers) and organic (e.g., manure) forms.
Planetary boundary	Safe limit set by the planetary boundary framework. This term is used for the planetary limit for the footprint metrics (phosphorous and nitrogen) that is directly linked to one of the nine planetary boundaries.
Planetary limits	The regulation of some human impacts on the environment—for example, the introduction of chemical contaminants—is often framed in the context of “safe limits”
Particulate matter	Tiny particles and/or droplets of liquid found in the air, including smoke, soot, and dust, etc.
Safe operating space	The safe operating space for a planetary boundary is any point before the zone of uncertainty in a planetary boundary. For each earth system, it is likely to be a threshold or ‘tipping point’ at which point catastrophic and largely irreversible change would occur. Before reaching the point at which the threshold or tipping point” is highly likely to be, we have a ‘zone of uncertainty’, defined by scientific uncertainties in how earth systems operate and in which the risk of reaching the threshold increases the larger the global footprint becomes. The safe operating space is the point at the beginning of the zone of uncertainty.
Tipping points	The point at which an ecosystem or ecological process can no longer cope with environmental change, and the ecosystem suddenly shifts from one state to another.

Water pollution	Water pollution is defined as the presence of toxic chemicals and biological agents that exceed what is naturally found in groundwater, lakes, rivers, or any other water bodies, and that may pose a threat to human health and/or the environment. Additionally, water pollution may consist of chemicals introduced into the water bodies as a result of various human activities. Any amount of those chemicals pollutes the water, regardless of the harm they may pose to human health and the environment.

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