Impacts of materials and their supply chains

Part 1: extraction

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Learning objectives

- Understand
  - The value of nature
  - Macro level view of degradation
  - How nature is critical to our economy and human health
- Towards reducing impacts, understand the current environmental and human health impacts of
  - Raw materials extraction
  - Use phase (engineered products)
  - End of life
- Explore best practice
  - 2020 Petro-chemical vs. 2050 NetZero/NetPositive

Now is the most exhilarating time to be an innovator.

Overview

- The value of nature
- Raw material extraction & transformation
- Use phase
- End of life
- 2020 Petro-chemical economy vs. 2050 NetZero

Phases in the life cycle of a product

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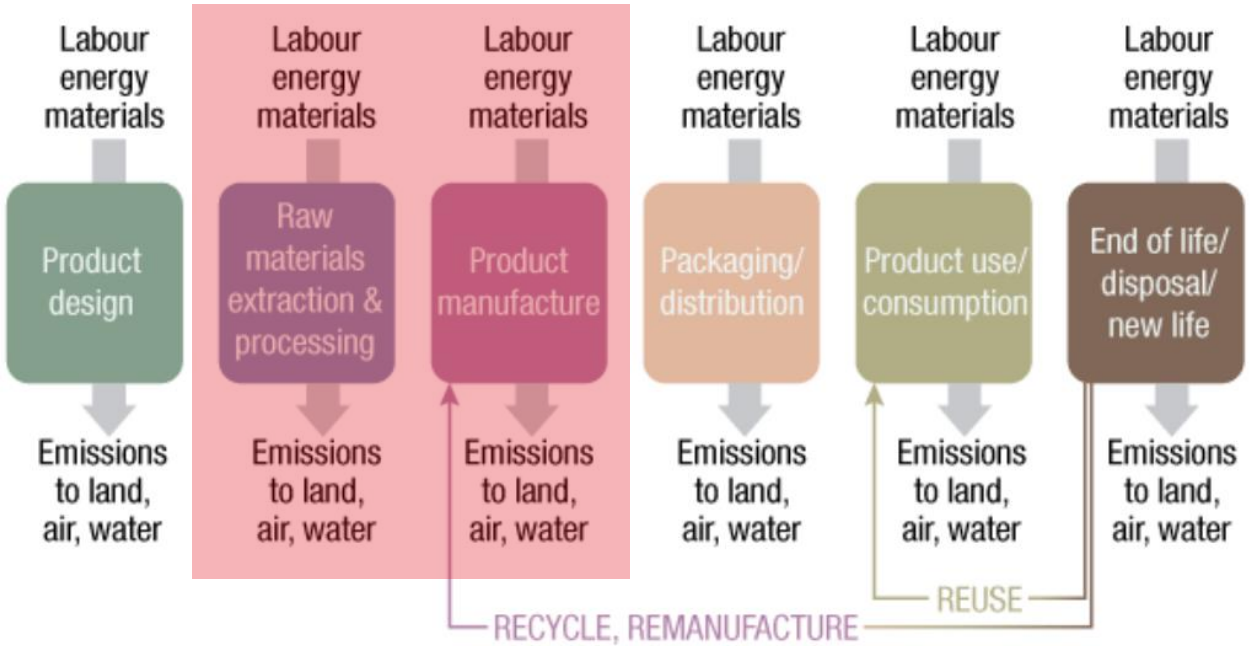
Figure 1: Phases in the life cycle of a product. Life Cycle Assessment (LCA) is a quantitative tool that facilitates the systematic quantitative assessment of products, in terms of environmental, human health, and resource consumption considerations. The methodology is internationally standardised by ISO 14040.



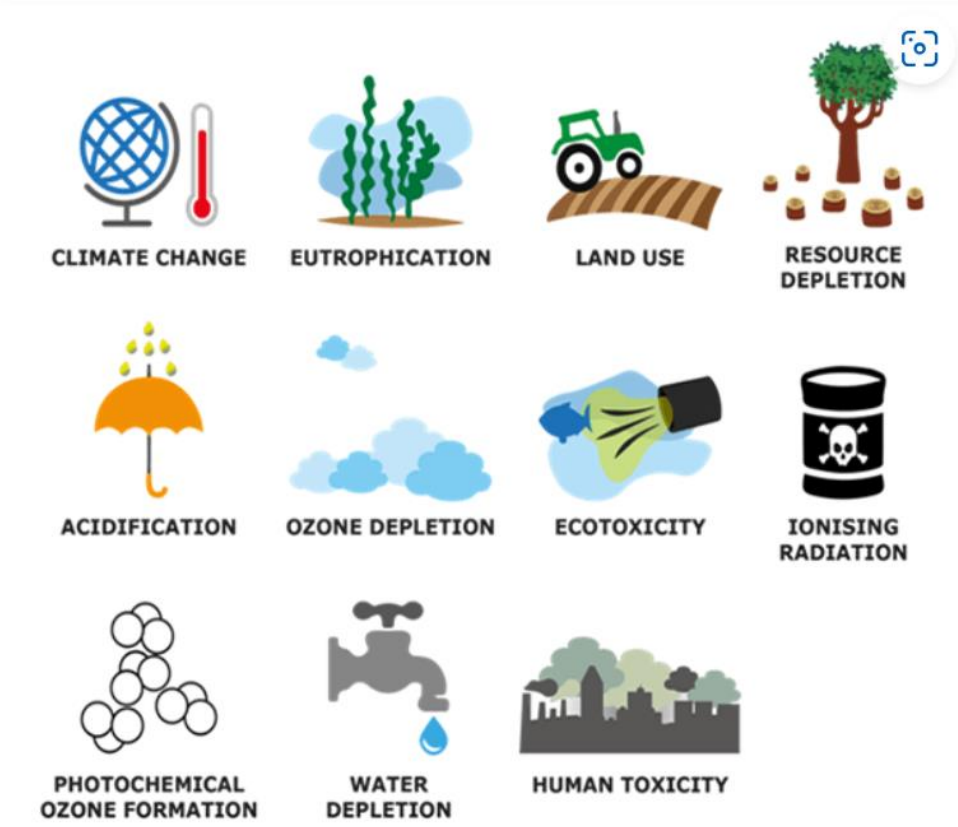
Source: Modified from UNEP Life Cycle Initiative.

RMIS - Environmental impacts along the supply chain

What types of impact?

- Environmental

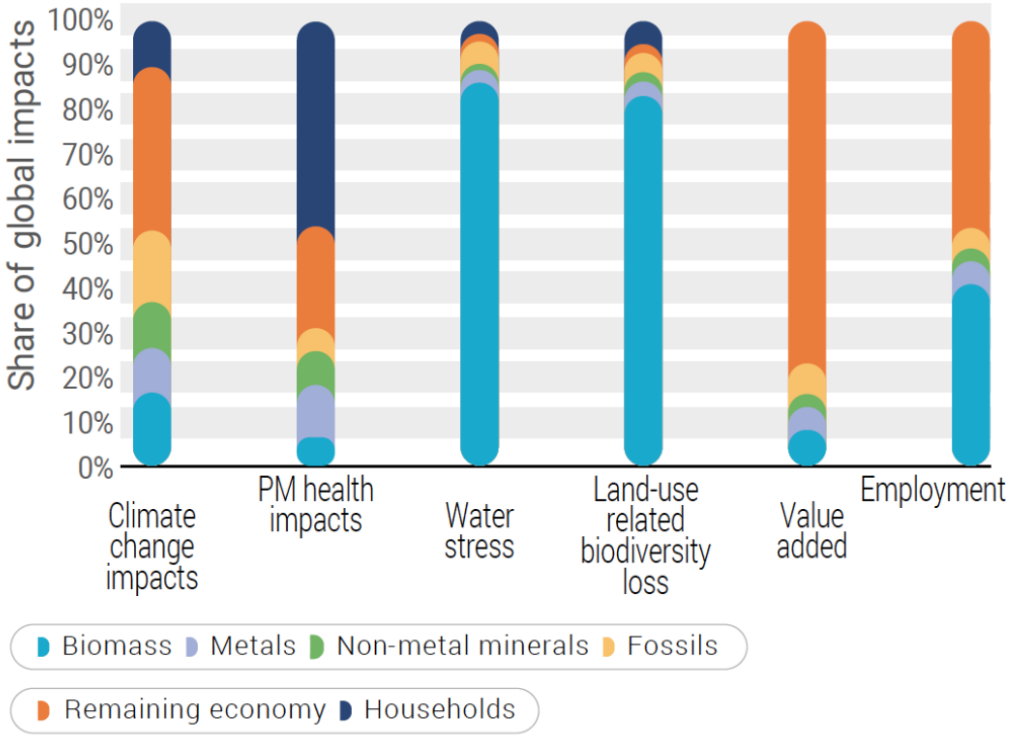
Figure 3: Environmental impact categories considered for LCA.



Source: European Platform on Life Cycle Assessment

RMIS - Environmental impacts along the supply chain

- Societal & cultural



Share of global impacts and socio-economic benefits between resource types (extraction and processing), the remaining economy and households (year 2011).
UNEP (2019). Note that biomass includes also energy and agricultural commodities.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

- Bio-diversity – the richness and variety of all life on Earth – is declining at every level from global to local, and across every region.
- These ongoing declines in nature, largely as a result of human activity, including climate change, have direct and dire impacts on food security and nutrition, water quality and availability, health and wellbeing outcomes, resilience to climate change and almost all of nature's other contributions to people.
- More than half of global GDP– more than $50 trillion of annual economic activity around the world – is moderately to highly dependent on nature.

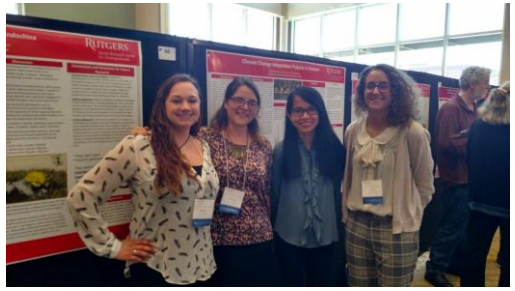
IPBES Digital Assets

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

- These unaccounted-for costs enhance private financial incentives to invest in economic activities that cause direct damage to nature
  - approximately $5.3 trillion per year
  - in spite of growing evidence of biophysical risks to economic progress and financial stability
- Also direct public subsidies to economic activities that have negative impacts on biodiversity
  - approximately $1.7 trillion per year
- Delayed action increases costs and increases the probability of irreplaceable losses such as species extinctions
  - Adds at least $500 billion per year in additional costs to meet policy targets.

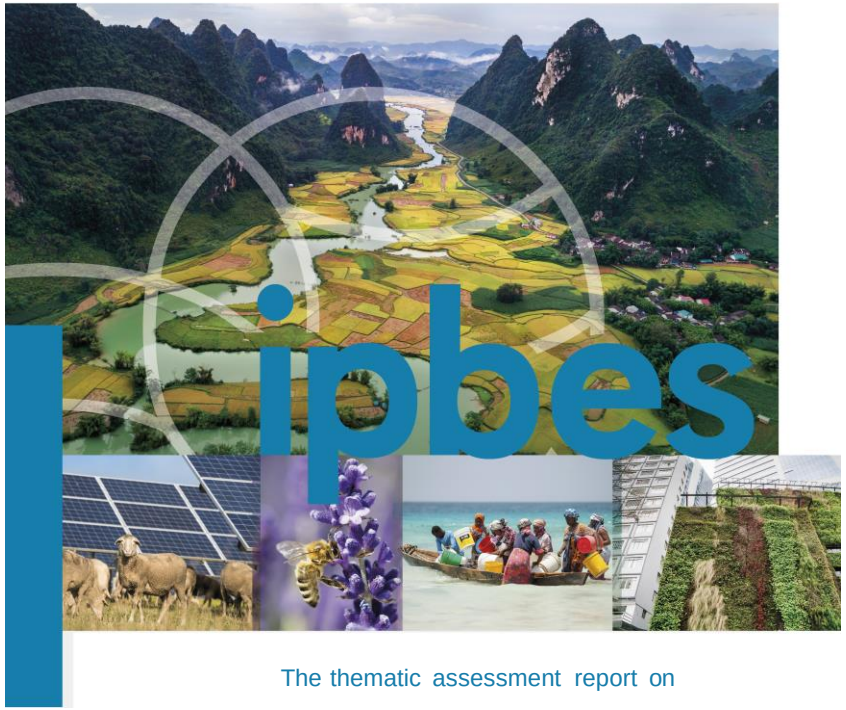
"But current decision-making has prioritized short-term financial returns while ignoring costs to nature, and failed to hold actors to account for negative economic pressures on the natural world. It is estimated that the unaccounted-for costs of current approaches to economic activity – reflecting impacts on biodiversity, water, health and climate change, including from food production – are at least $10-25 trillion per year," said Prof. McElwee.

IPBES Digital Assets

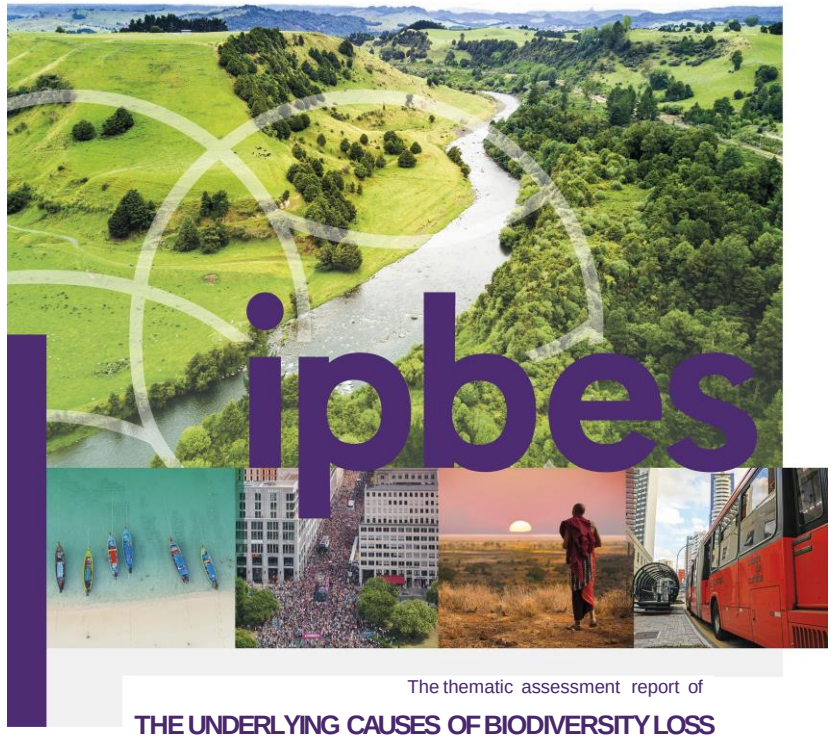


Our world, our gift, our home

- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)



IPBES Digital Assets



IPBES Digital Assets

We need a systemic view

- The review of scientific evidence by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) found governments are underestimating or ignoring the links between five key areas - biodiversity, water, food, health and climate change.
- This "siloed" approach has unintended consequences, such as damaging biodiversity through tree-planting schemes, or polluting rivers while ramping up food production, the report said.

Nature's true value overlooked in decision making - IPBES

11 July 2022

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Helen Briggs
Environment correspondent

Nature has multiple values that aren't all recognising in policy, say scientists

Nature's true value overlooked in decision making - IPBES

BBC Register

Home News Sport Business Innovation Culture Arts Travel Earth Video Live

Major report joins dots between world's nature challenges

20 hours ago

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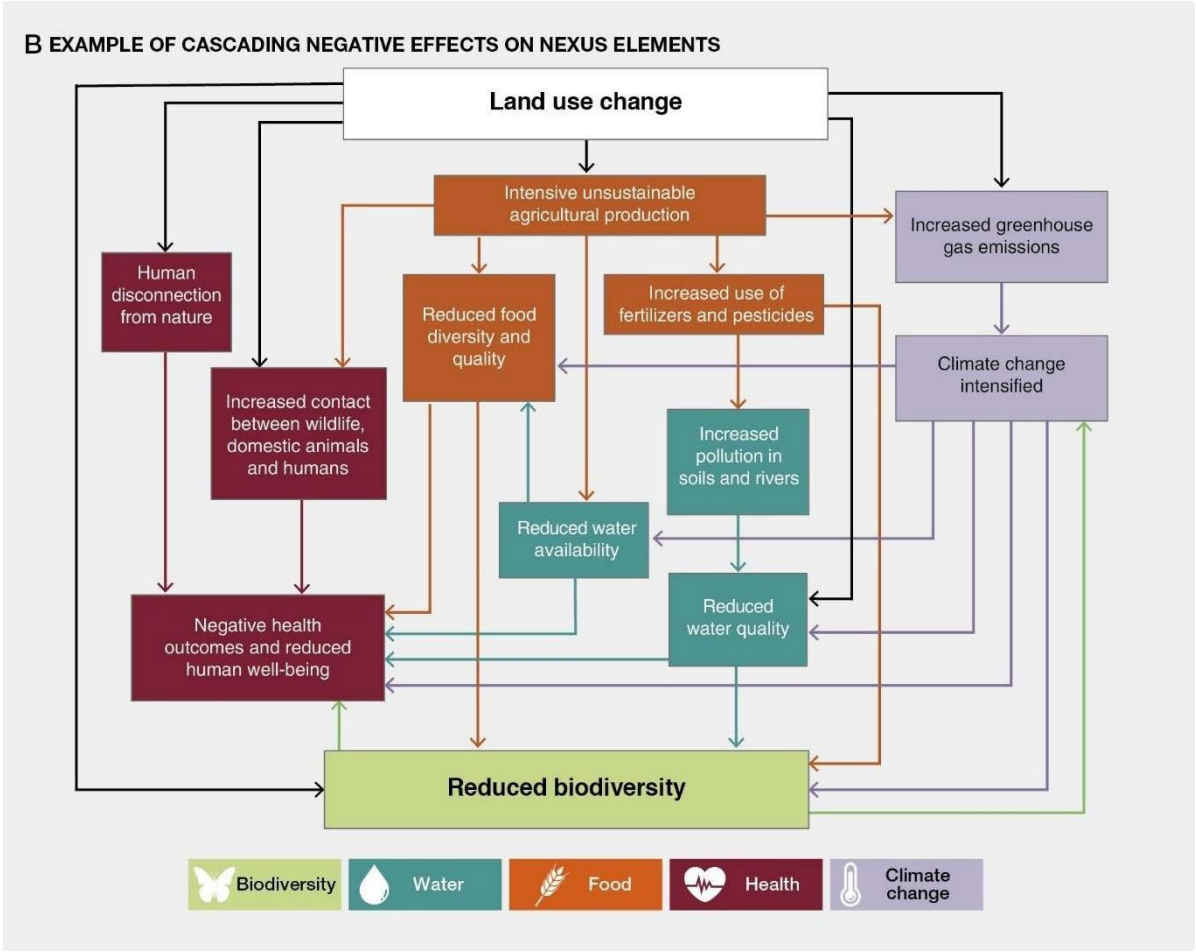
Helen Briggs
Environment correspondent, BBC News @hbriggsjourno.bsky.social • @hbriggs

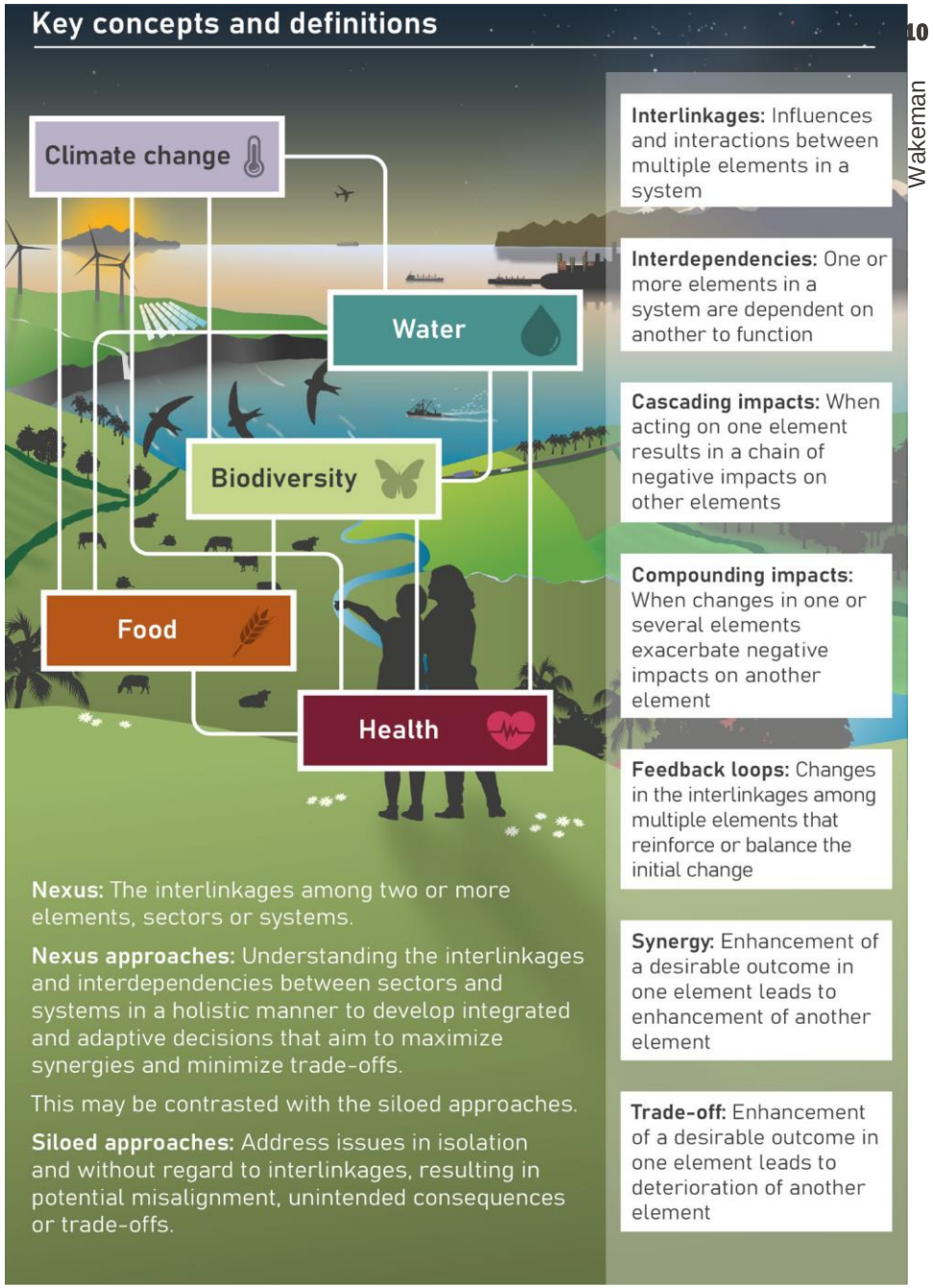
Issues like climate chante, biodiversity and water are all interlinked, the report says

IPBES report sees climate, nature and food challenges interlinked

Interlinkages between two or more systems



IPBES Digital Assets



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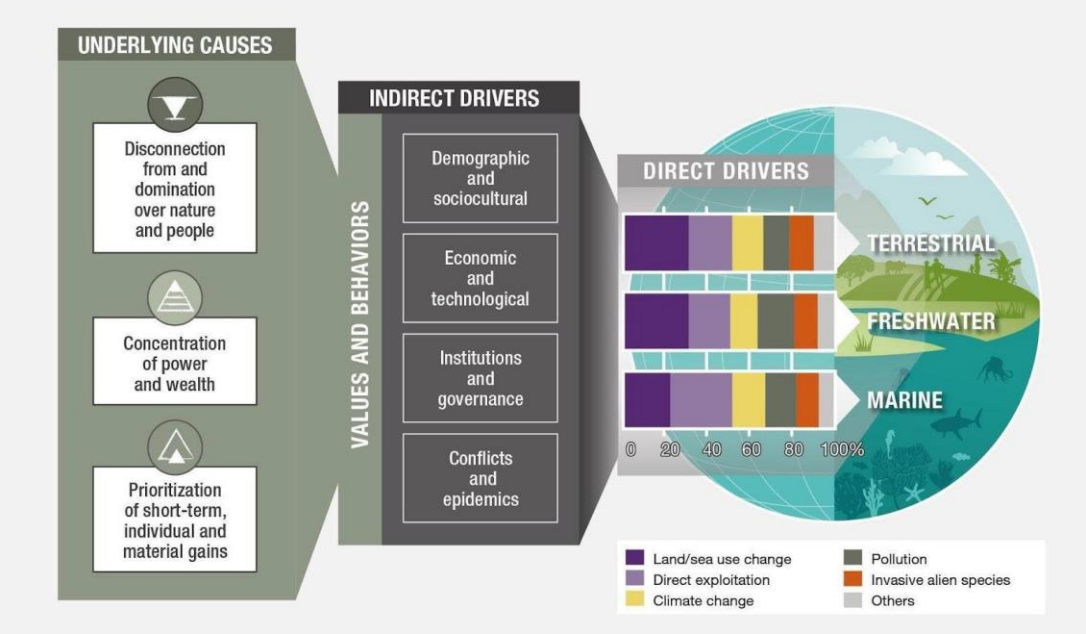
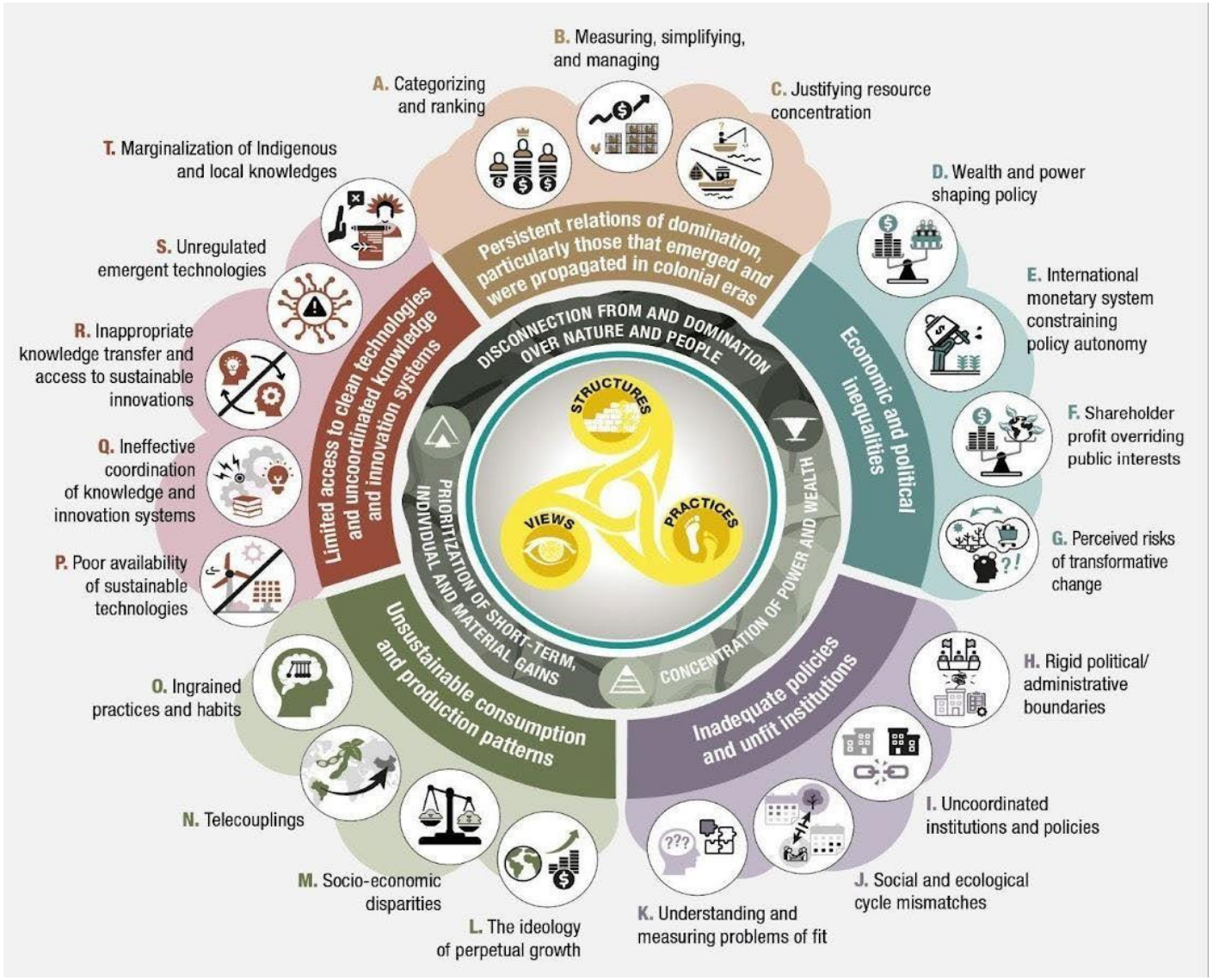
Underlying causes of bio-diversity loss



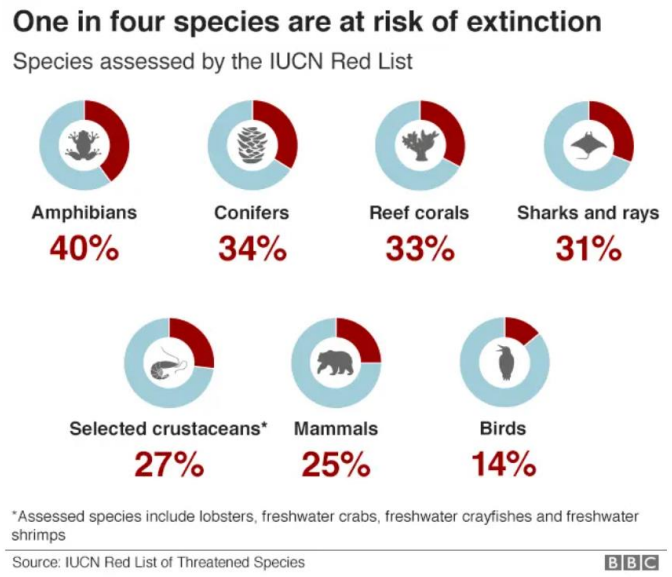


- Underlying causes, indirect drivers and direct drivers of biodiversity loss and nature's decline.
- Wheel of the interconnected challenges (different colors) and barriers (different letters) to transformative change

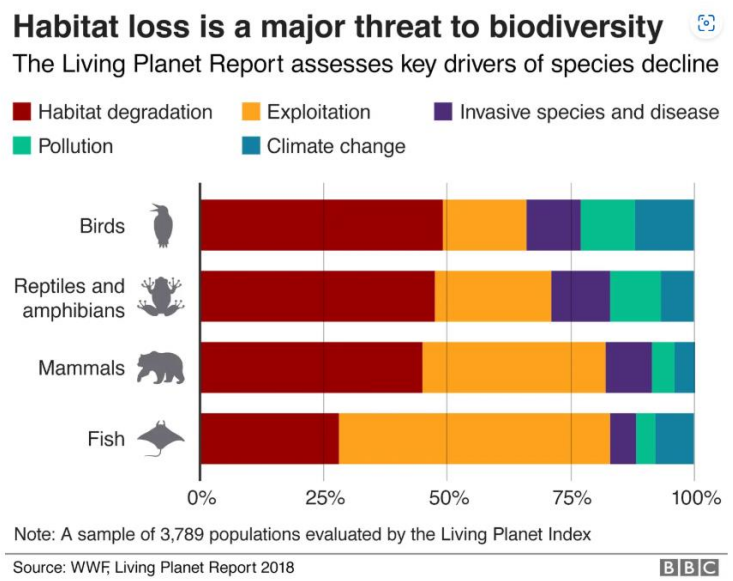
IPBES Digital Assets

Extinction rate

- Current extinction rates are about 1,000 times higher than before humans came along, and future rates are likely to about 10,000 times higher, according to estimates.



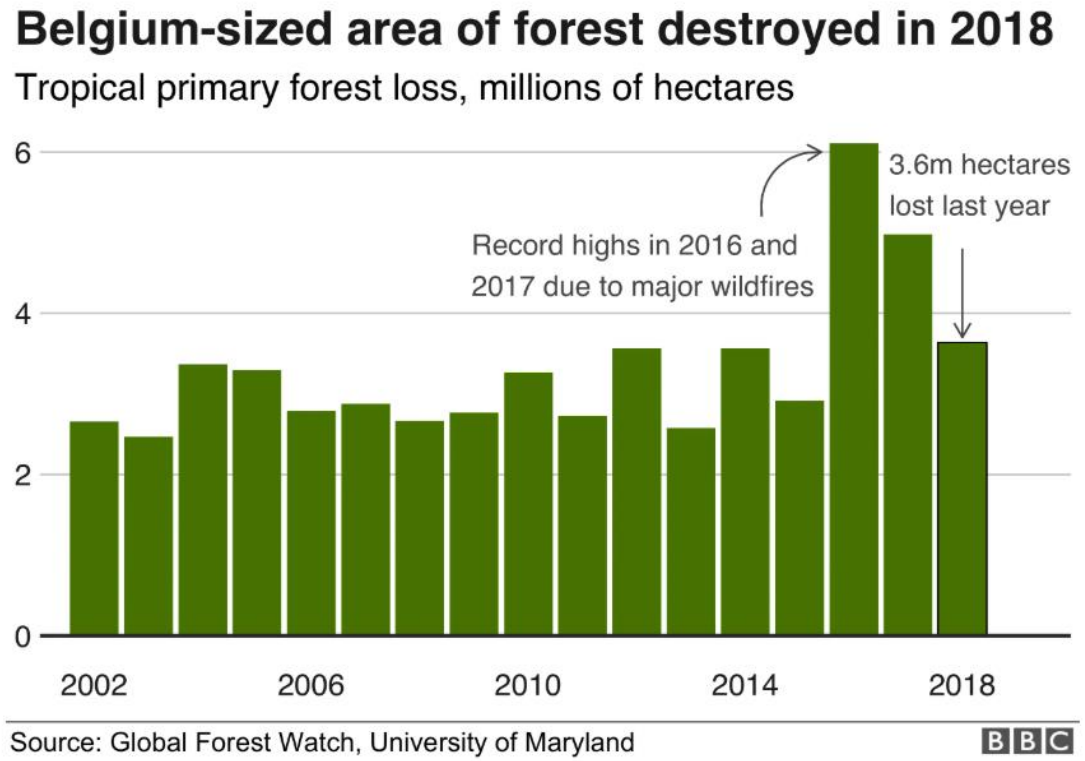
Nature's emergency: Where we are in five graphics

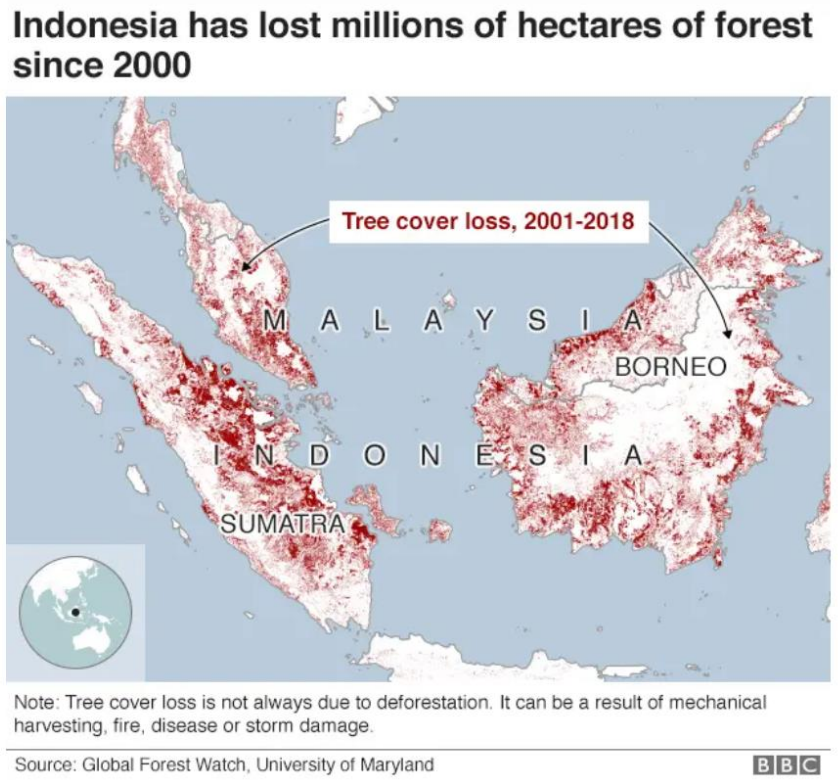


The faces of extinction – Europe For Nature

Animals and plants are disappearing and so is the land they rely upon for natural habitat

- Since 2001, Indonesia has lost millions of hectares of pristine rainforest.
- Losses in 2018 declined by around 40% thanks to stricter government legislation and a wet period that limited forest fires, but nonetheless palm oil plantations have gradually eroded the only remaining habitats of endangered orangutan populations.



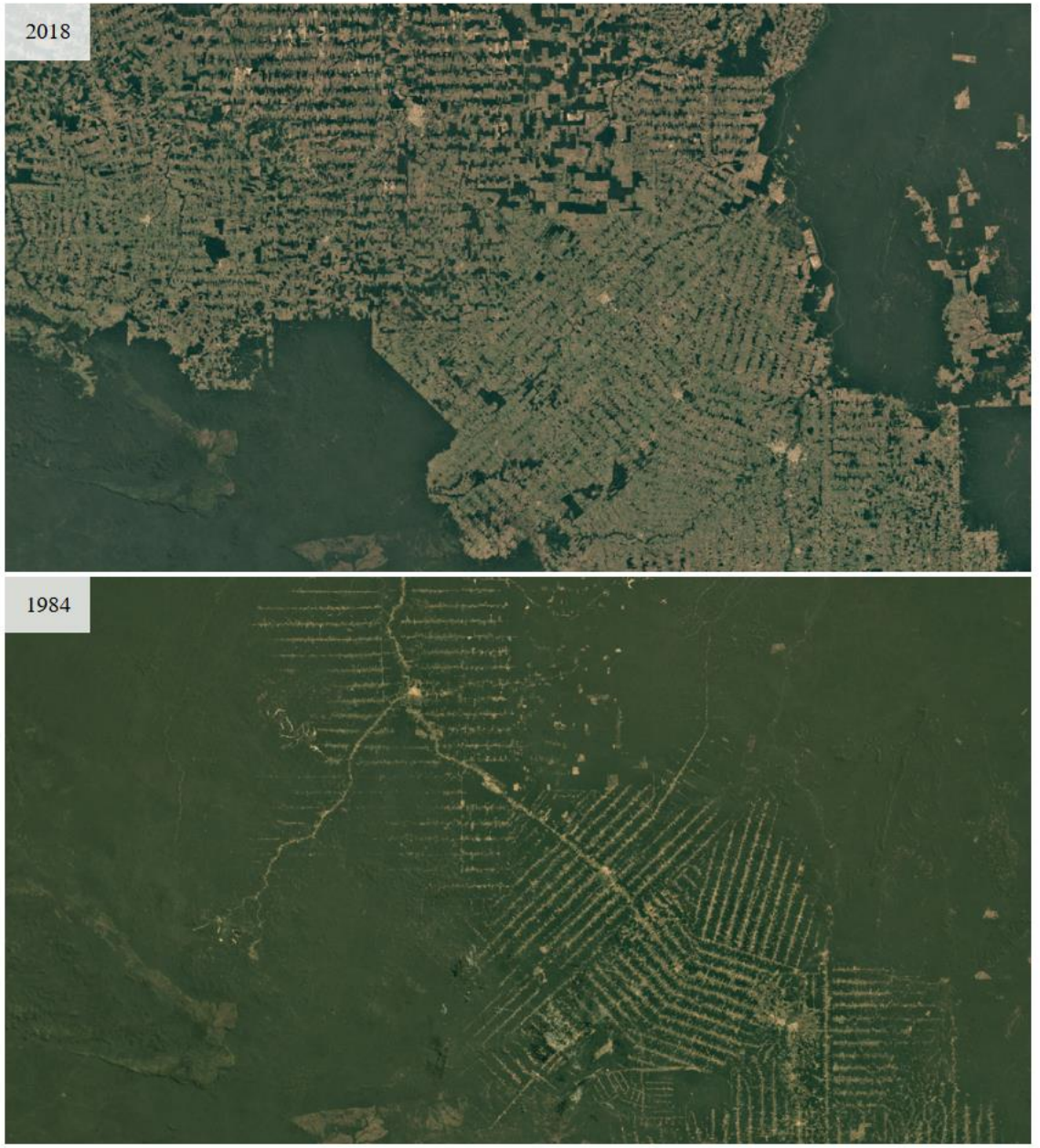


Nature's emergency: Where we are in five graphics

Some of the last great rainforests are being wiped out

- Amazon region holds the largest tropical rainforest in the world, which is home to plant and animal species that are stil being discovered.
- Rondônia, in the western part of the Amazon, is one of the most deforested parts, cut down for crops or for pastures to graze cattle, as well as for logging and mining.
- Over time, the landscape becomes a mixture of cleared fields, settlements and fragments of forest.

Nature's emergency: Where we are in five graphics



slido

Please download and install the Slido app on all computers you use

What do you think we could do to address the serious decline in bio-diversity?

ⓘ Start presenting to display the poll results on this slide.

Policy - Green deal

- Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation **policies fit for reducing net greenhouse gas emissions by at least 55% by 2030**, compared to 1990 levels.

Cleaning our energy system

Reducing greenhouse gas emissions by at least 55% by 2030 requires higher shares of renewable energy and greater energy efficiency.

40%
new renewable energy target for 2030

36-39%
new 2030 energy efficiency targets for final and primary energy consumption

Making transport sustainable for all

Our transition to greener mobility will offer clean, accessible and affordable transport even in the most remote areas.

The European Commission proposes more ambitious targets for reducing the CO2 emissions of new cars and vans.

55%
reduction of emissions from cars by 2030

50%
reduction of emissions from vans by 2030

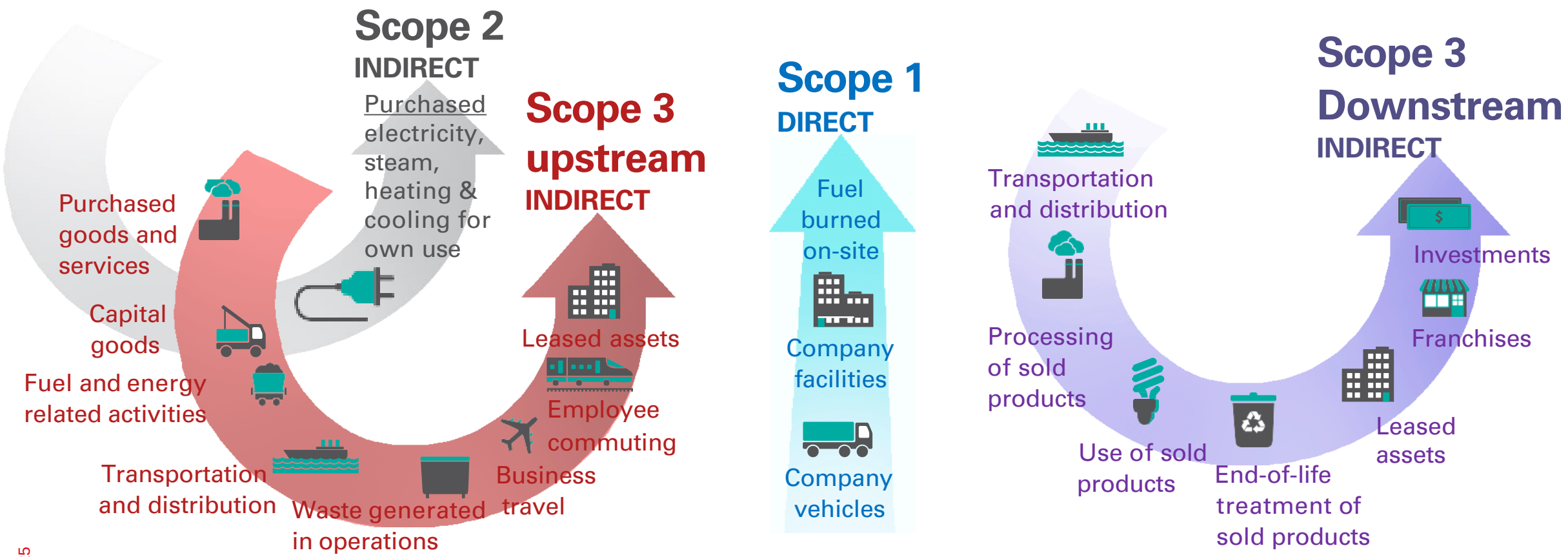
0
emissions from new cars by 2035

Transport emissions decrease by 90% by 2050 to meet GD objectives.

A European Green Deal | European Commission (europa.eu)

Scope 1, 2, 3 emissions

CO_2 CH_4 N_2O HFCs PFCs SF_6

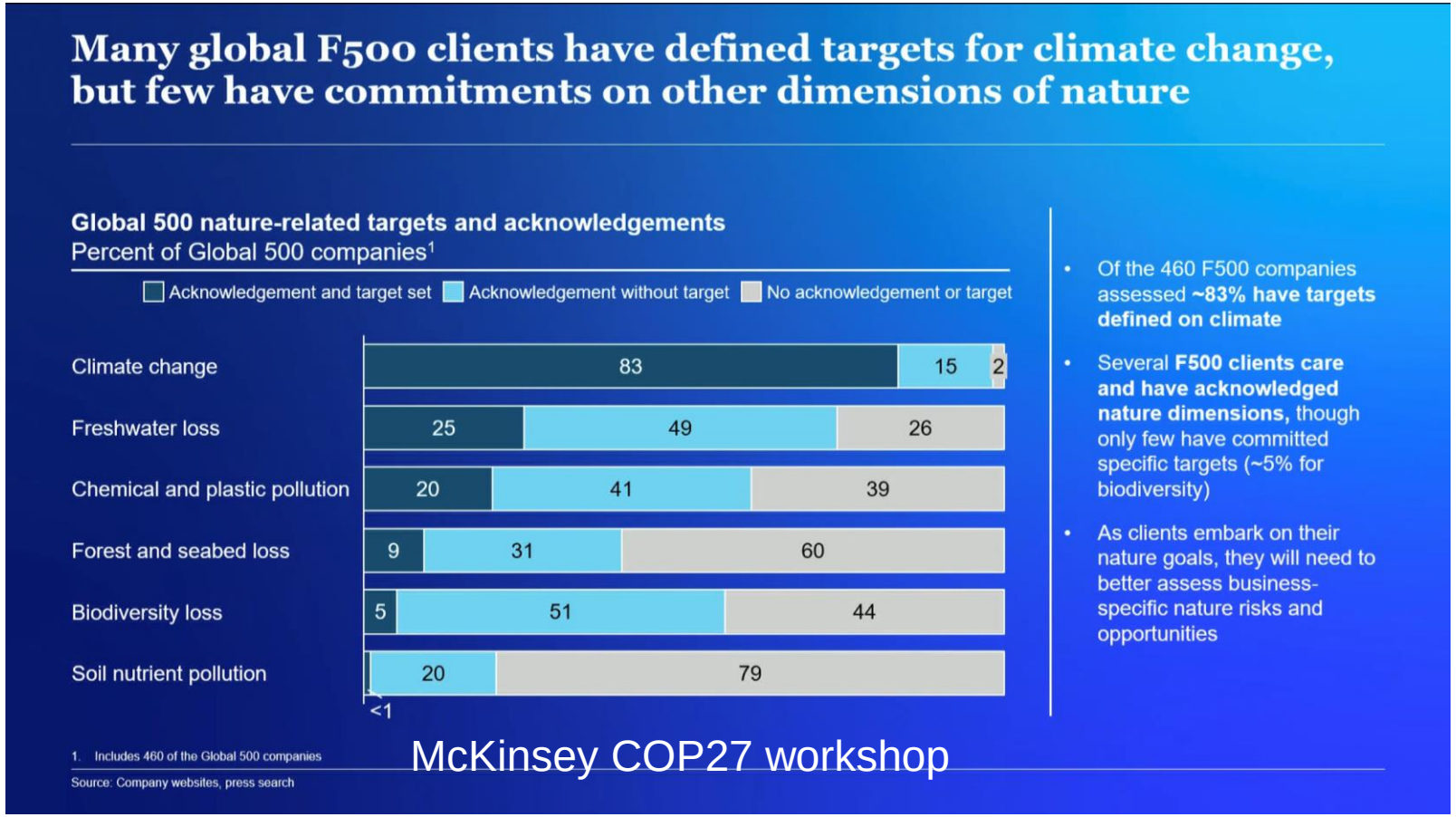


Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

We need wider IMPACT metrics

Wider metrics beyond climate change, environment and society

Redirect capital to locations which will see the strongest effects of climate change yet have contributed less towards cumulative emissions

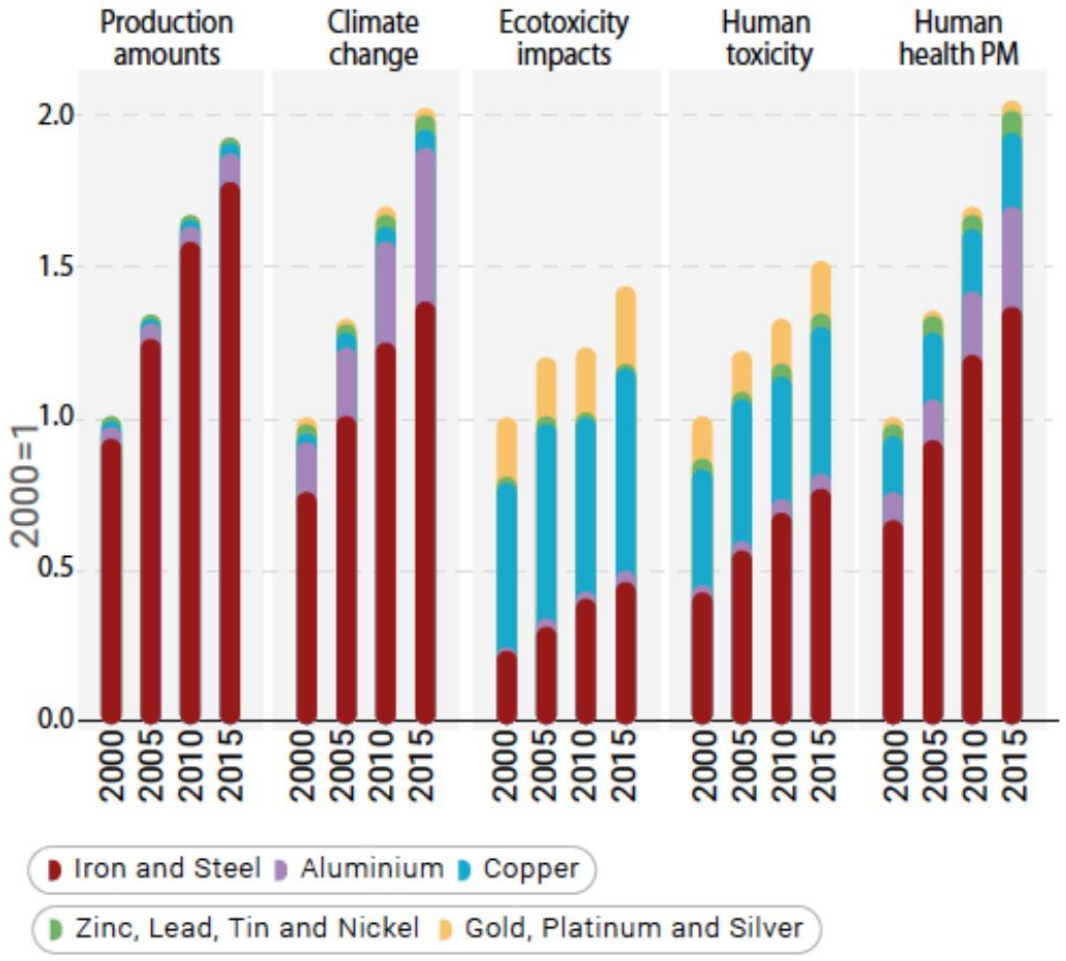


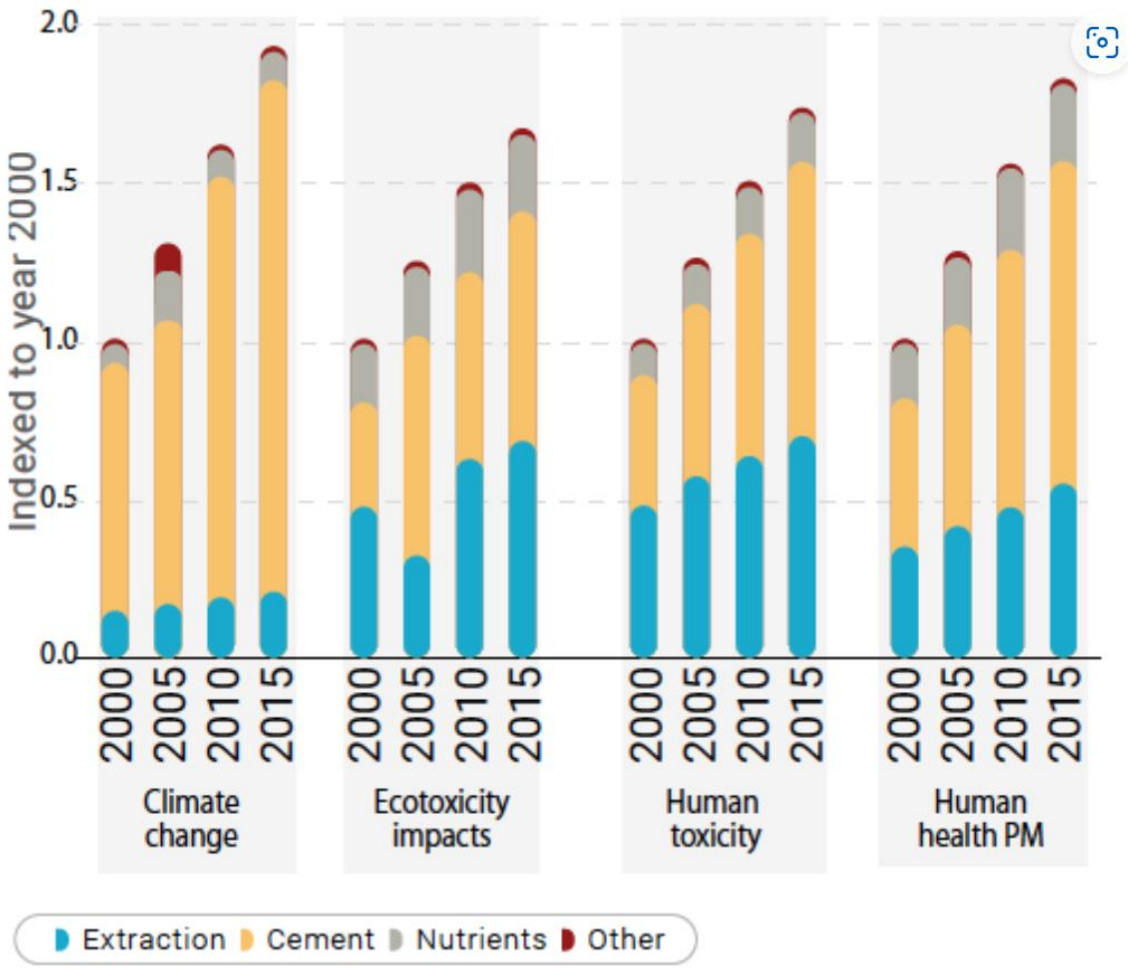
McKinsey COP27 workshop

Overview

- The value of nature
- Raw material extraction & transformation
- Use phase
- End of life
- 2020 Petro-chemical economy vs. 2050 NetZero

Environmental impacts of metal mining (left) and of non-metallic minerals extraction and processing (right) over time





RMIS - Environmental impacts along the supply chain

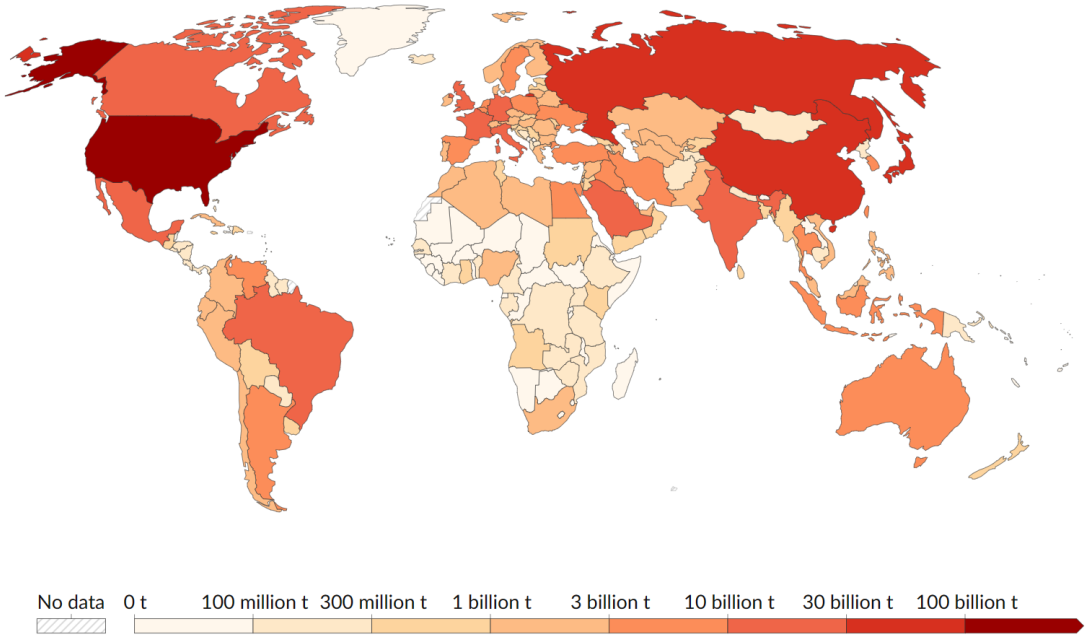
CO2e emissions from oil and industry, 2022

Wakeman

Cumulative CO_2 emissions from oil, 2022

Cumulative emissions of carbon dioxide (CO_2) from oil since the first year of available data, measured in tonnes.

Our World in Data



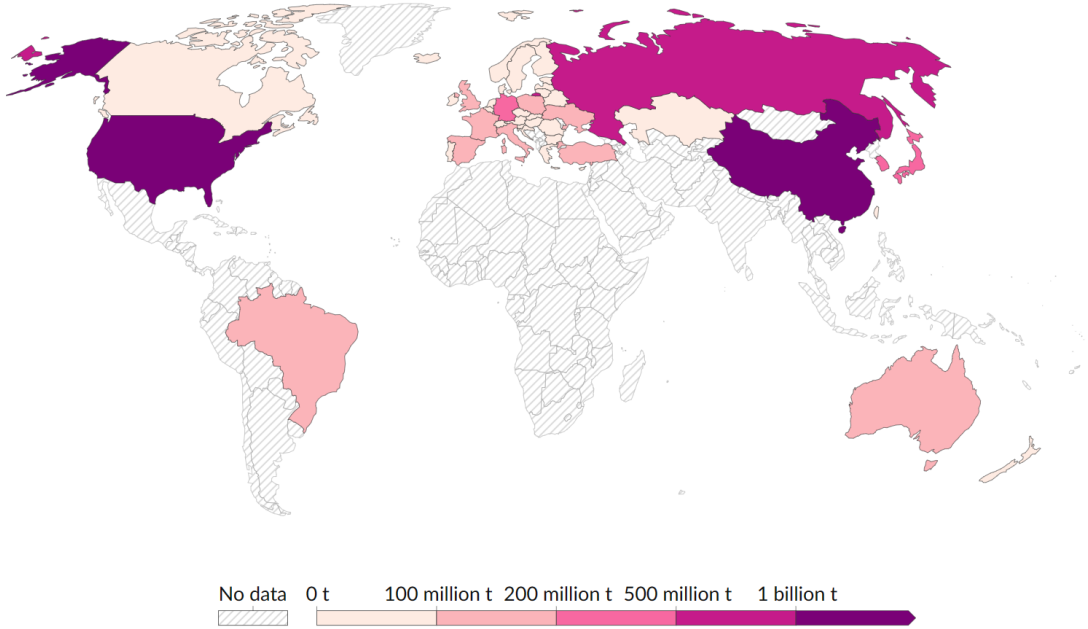
Data source: Global Carbon Budget (2023)

OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

Cumulative CO_2 emissions from other industry, 2022

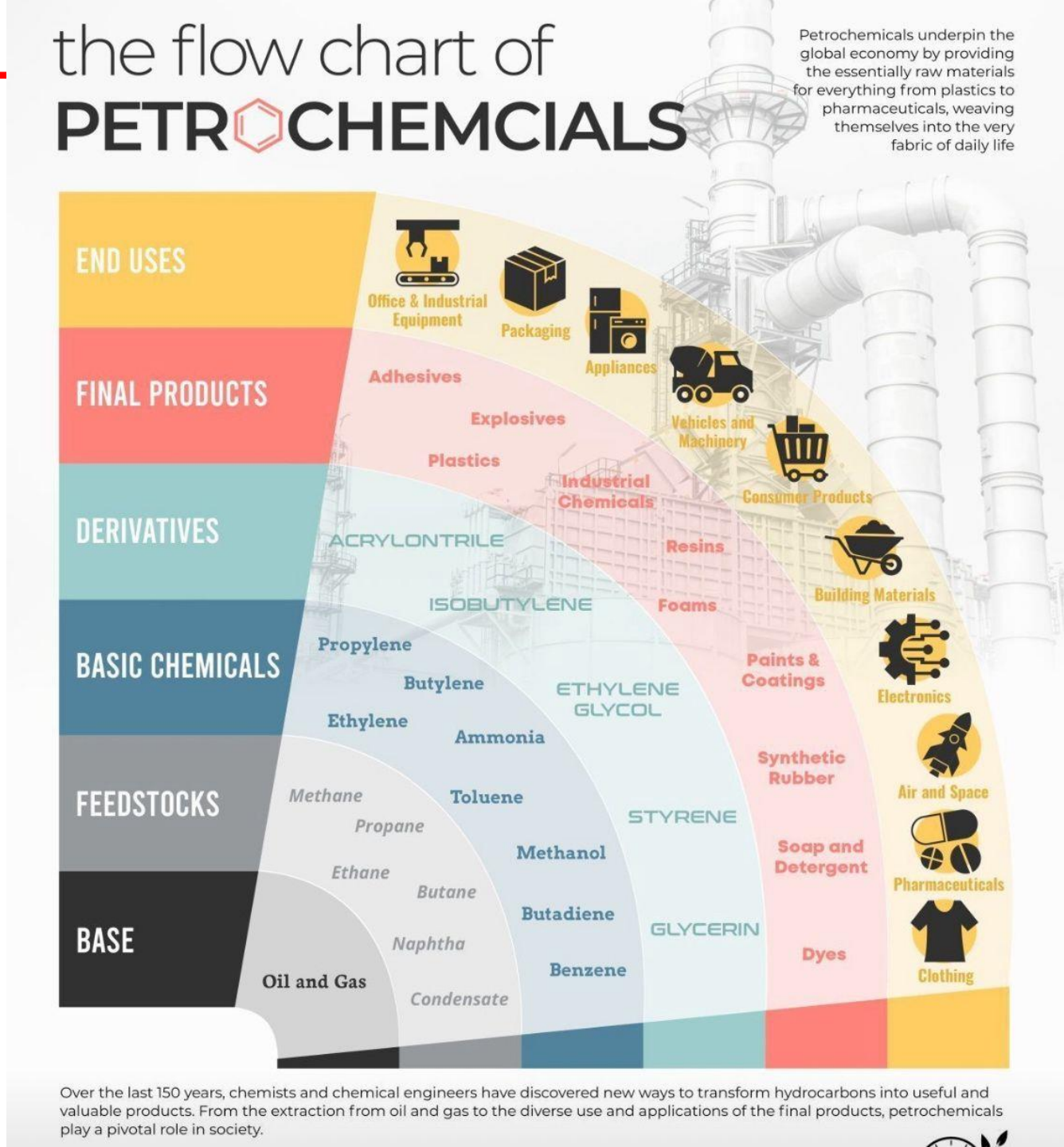
Cumulative emissions of carbon dioxide (CO_2) from other industry sources since the first year of available data, measured in tonnes.

Our World in Data



Data source: Global Carbon Budget (2023)

OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY



“ The chemical industry uses a small set of raw materials or feedstocks to produce tens of thousands of products,…

EllenMacArthur_White Paper_2019.pdf

CAS data base covers more than 400’000 different substances but not all are produced regularly …
Number of chemicals regularly produced at industrial scale = 30’000 to 40-50’000

Produced from a small number of Petro-chemical feedstocks and basic chemicals and derivatives

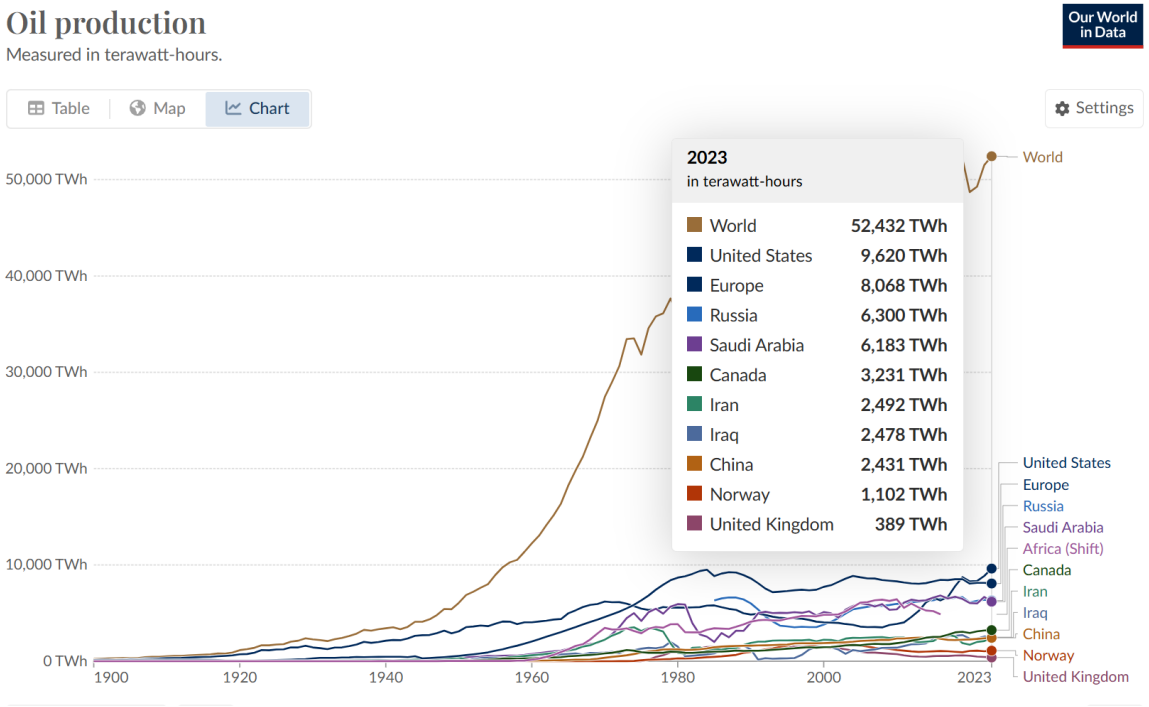
Need to operate upstream on few derivatives to impact many products

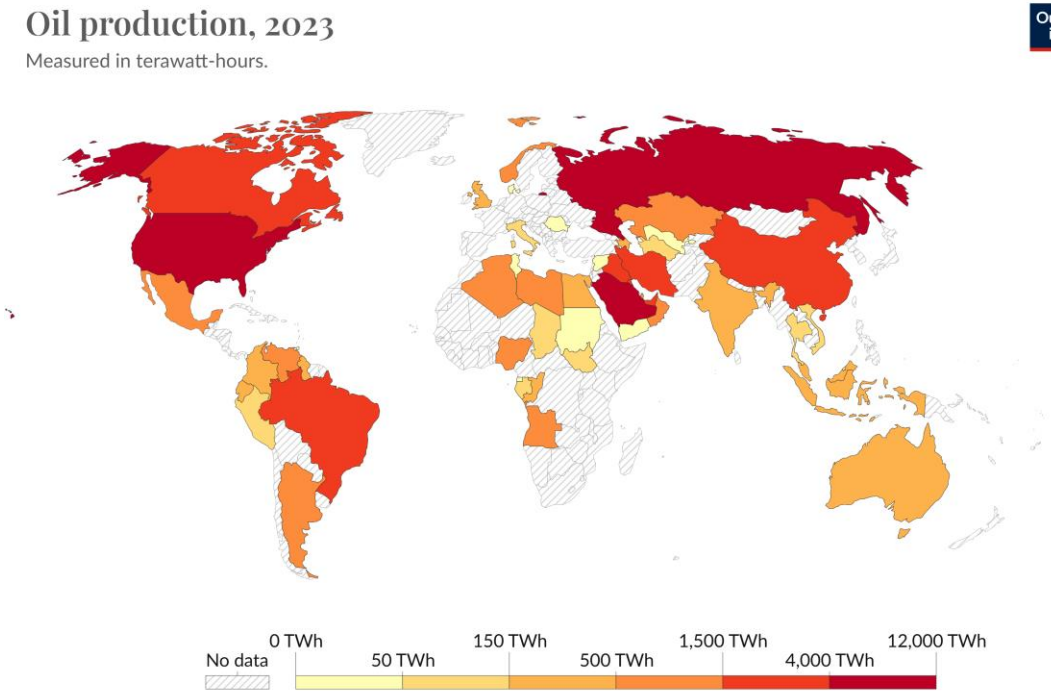
EllenMacArthur_White Paper_2019.pdf

CAS Content | CAS

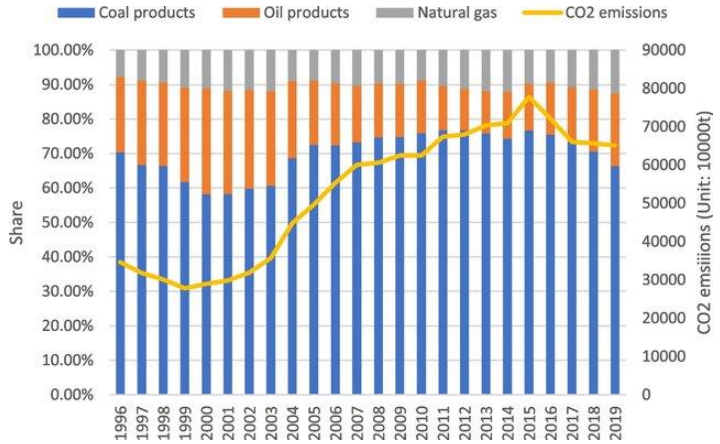
Chemicals in Commerce - International Council of Chemical Associations (ICCA) (icca-chem.org)

Oil extraction

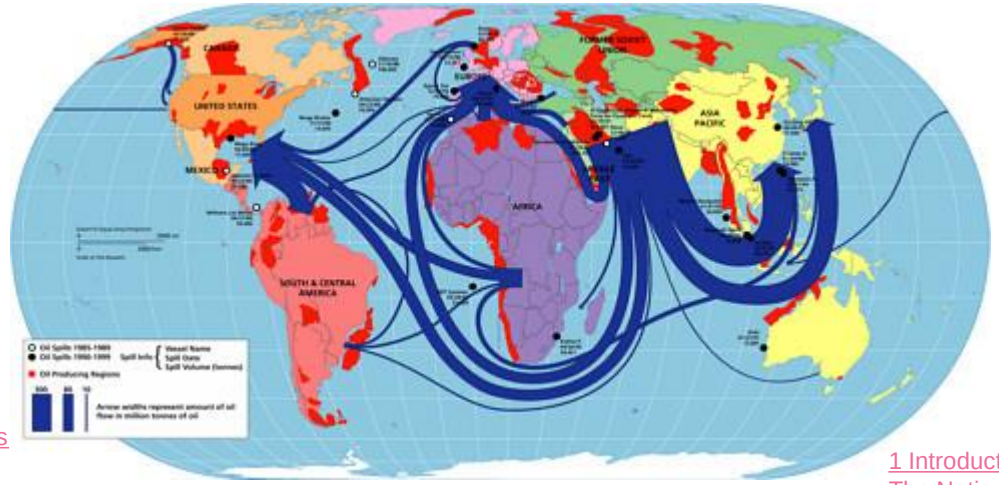




Oil production



Decoupling trend and emission reduction potential of CO2 emissions from China's petrochemical industry - PubMed



Worldwide sea borne flow of oil in 2000 (modified from Newton, 2002; other information sources include U.S. Geological Survey, U.S. Coast Guard, Minerals Management Service). Solid black dots indicate spills included in the average, annual (1990-1999) estimates

1 Introduction | Oil in the Sea III: Inputs, Fates, and Effects | The National Academies Press

Petroleum refineries

- Source of toxic air pollutants, BTEX compounds, carbon monoxide, particulate matters, and sulfur dioxide.
- Suspected cancer-causing agents, also responsible for the development of reproductive problems, and respiratory complications.
- Major contaminators of surface and ground water.
- The deep wells for the disposal of waste material end up in aquifers and ground water.
- Some refineries also discharge untreated waste material into water bodies such as lakes and rivers.
- The petroleum products that find their ways into the water bodies are also highly inflammable and may cause river fires (Cuyahoga River).
- May also contaminate soil (hazardous waste, oil spills, sludge from the treatment process, and coke dust).
- Reduces the fertility of the soil and introduces foreign particles which may affect the growth and quality of crops.

What Is The Environmental Impact Of The Petroleum Industry? - WorldAtlas

shalegas_pe464425_exec-presentation_en.pdf

BTEX mixtures of benzene, toluene, and the three xylene isomers, all of which are aromatic hydrocarbons.
BTEX are **highly toxic environmental compounds** that have carcinogenic and mutagenic effects in humans.

Oil extraction goes wrong: $4.5 B fine

BP gets record US criminal fine over Deepwater disaster

15 November 2012

The Deepwater Horizon disaster caused one of the worst oil spills in history

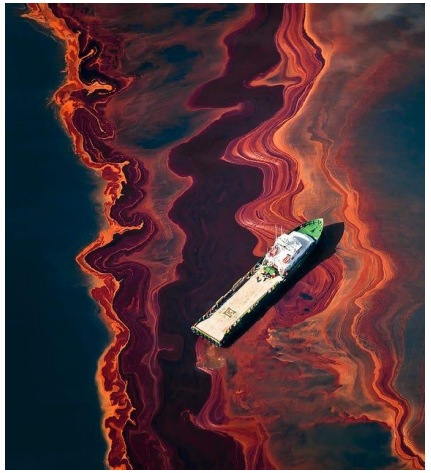
BP has received the biggest criminal fine in US history as part of a $4.5bn (£2.8bn) settlement related to the fatal 2010 Deepwater Horizon disaster.

Two BP workers have been indicted on manslaughter charges and an ex-manager charged with misleading Congress.

The Department of Justice (DoJ) said BP must hand over $4bn. The sum includes a $1.26bn fine as well as payments to wildlife and science organisations.

As part of the agreement, BP will also plead guilty to 14 criminal charges.

The company apologised for its role and said it regretted the loss of life.

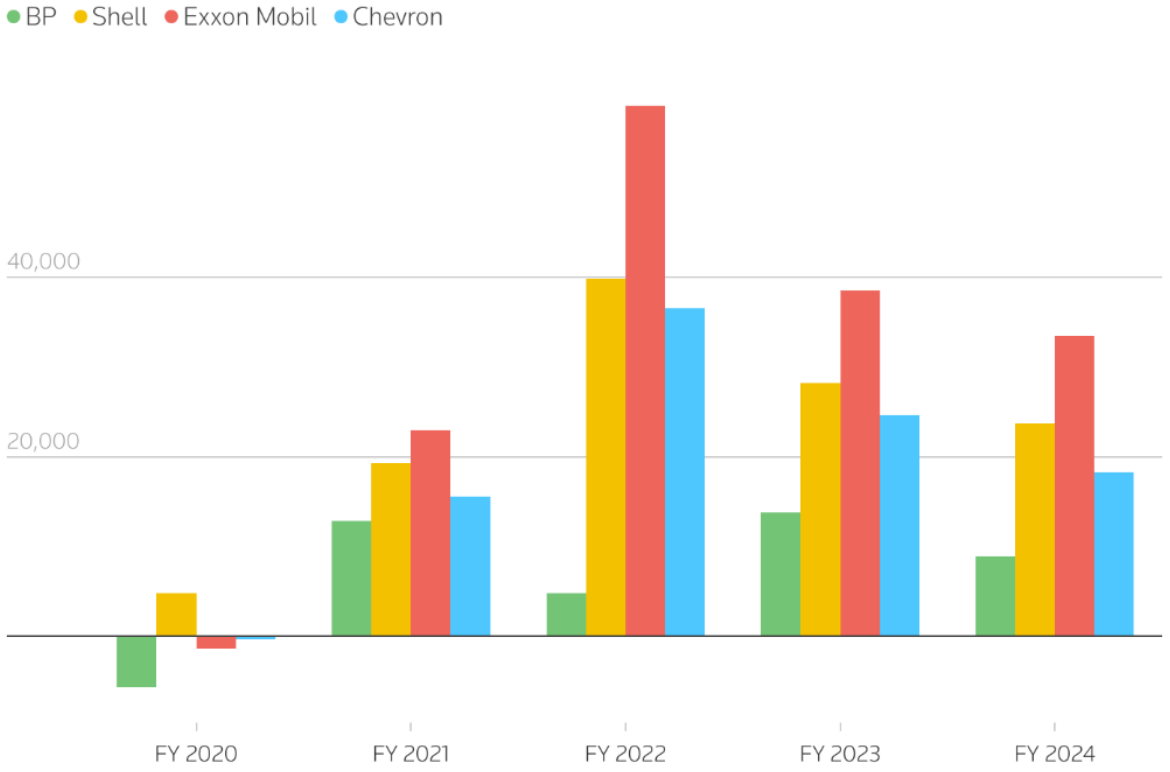


bp deepwater horizon oil spill - Search Images

BP focus changing

- BP under pressure to boost returns from Elliott Investment Management
- BP's shares have underperformed rivals

- BP's chief executive will scrap a target to increase renewable generation 20-fold by 2030, returning the focus to fossil fuels, as part of a strategy shift announced on Wednesday to tackle investor concerns over earnings, two sources told Reuters.
- BP's shares have underperformed rivals in recent years and the oil major has already dropped its target to cut oil and gas output by 2030,



Reuters World Business Markets Sustainability Legal Breakingviews Technology Investigations More

Exclusive: BP to ditch renewables goals and return focus to fossil fuels

By **Arunima Kumar** and **Anousha Sakoui**

February 24, 2025 5:37 PM GMT+1 · Updated 4 days ago

Conversion into semi-finished products (PFOA)

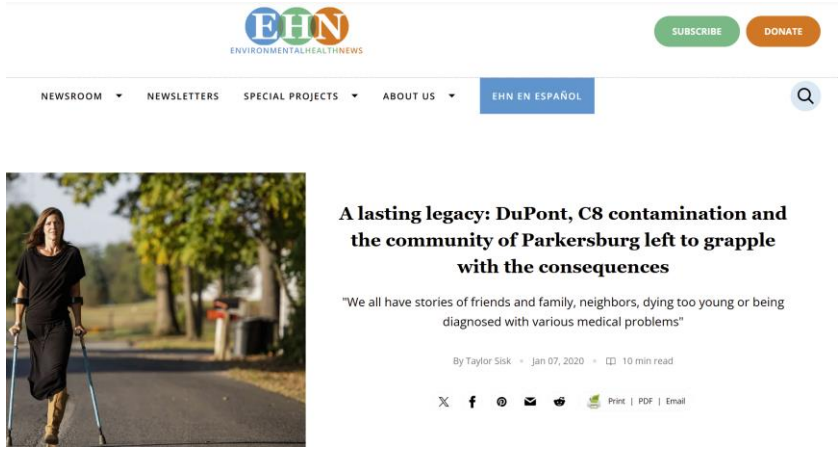
- Invented in 1930's, 3M produced as processing aid for Teflon
- **1951** "DuPont chemical plant, Washington, West Virginia, used PFOA in its manufacturing process."
- An organic molecule has bonds of carbon and hydrogen atoms.
- To make PFAS molecules, you replace the hydrogen with fluorine.
- PFAS molecules with chains of fluorine-carbon bonds, incredibly difficult to break.
- Mainly used as surfactants — they repel oil and water. So when you have a spill on your furniture, and want to keep it clean, then PFAS are often added. Also food wrappings.
- The updated REACH regulations specify that PFOA shall not be manufactured, or placed on the market, to take effect from 4th July 2020.
- Chemical manufacturing contributes an estimated 300,000 to 750,000 DALYs

US EPA cites Chemours for releases of GenX-related chemicals

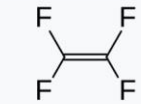
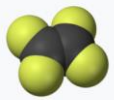
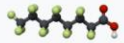
Per- and polyfluoroalkyl substances (PFAS) - ECHA

Petroleum-based-Polymers

PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites | Environmental Sciences Europe | Full Text



A lasting legacy: DuPont, C8 contamination and the community of Parkersburg left to grapple with the consequences - EHN

Compound	Chemical formula	Structural model	3D image	Other names	Notes
Tetrafluoroethylene (TFE)	C_2F_4			Tetrafluoroethene, Perfluoroethylene, Perfluoroethene	Precursor to PTFE (Teflon)
Perfluorooctanoic acid (PFOA)	$C_8HF_{15}O_2$			perfluorooctanoic acid, PFOA, C8, perfluorooctanoate, perfluorocaprylic acid, FC-143, F-*n*-octanoic acid, PFO	

Timeline of events related to per- and polyfluoroalkyl substances - Wikipedia

Policy - Reach (chemicals and their use, e.g. in polymers)

Wakeman

European Commission

English EN

Internal Market, Industry, Entrepreneurship and SMEs > Sectors > Chemicals > REACH

Chemicals

- EPAA - Alternative Approaches to Animal Testing
- Chemicals strategy
- What the Commission is doing
- **REACH**
  - How REACH Works

REACH

REACH is the European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals. It entered into force in 2007, replacing the former legislative framework for chemicals in the EU.

REACH shifts the responsibility from public authorities to industry with regards to assessing and managing the risks posed by chemicals and providing appropriate safety information for their users. It impacts on a wide range of companies across many sectors beyond the chemical industry. It requires new forms of cooperation among companies, enhancing communication along the supply chain, as well as developing tools to guide and assist companies and public authorities in its implementation.

REACH: Registration, Evaluation, Authorization, and Restriction of Chemicals

Substances restricted under REACH - ECHA (europa.eu)

Chemical industry

Wakeman

- Precursors to make many advanced materials
- The chemical industry has significant impacts on both the environment and human health. Here are some key points:

Environmental Impacts

1. **Air Pollution**: Chemical manufacturing releases pollutants such as volatile organic compounds (VOCs), nitrogen oxides, and sulfur dioxide, contributing to smog, ground-level ozone, and respiratory issues
2. **Greenhouse Gas Emissions**: The industry is a notable source of greenhouse gases, including carbon dioxide and methane, which contribute to climate change
3. **Water Pollution**: Chemicals and heavy metals can contaminate water bodies, harming aquatic life and making water unsafe for human consumption
4. **Soil Contamination**: Hazardous chemicals can degrade soil quality, affecting agriculture and natural vegetation
5. **Resource Depletion**: The production processes often rely on non-renewable resources, leading to their depletion

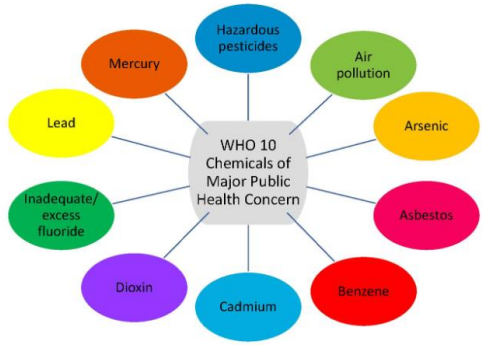
Human Health Impacts

1. **Acute Health Effects**: Exposure to hazardous chemicals can cause immediate health issues such as skin and eye irritation, burns, and poisoning
2. **Chronic Health Effects**: Long-term exposure can lead to serious conditions like cancer, respiratory diseases, cardiovascular problems, and reproductive issues
3. **Occupational Hazards**: Workers in the chemical industry face risks of exposure to toxic substances, necessitating strict safety measures
4. **Community Health Risks**: Communities near chemical plants may experience higher rates of health problems due to environmental contamination

- Efforts to mitigate these impacts include stricter regulations, improved safety protocols, and the development of greener technologies.

The Impact of Chemical Manufacturing on the Environment

Chemical industry examples



Specific Chemicals

1. **Asbestos**: Used in construction materials for insulation and fireproofing. It can cause lung cancer, mesothelioma, and asbestosis when inhaled
2. **Benzene**: Found in industrial solvents and gasoline. Long-term exposure can lead to leukemia and other blood disorders
3. **Lead**: Used in batteries, paints, and pipes. It can cause neurological damage, especially in children
4. **Mercury**: Found in thermometers, dental fillings, and industrial processes. It can damage the nervous system and kidneys
5. **Polychlorinated Biphenyls (PCBs)**: Used in electrical equipment and other industrial applications. They are carcinogenic and can cause liver damage.
6. **…**

Companies

1. **Dow Chemical Company**: Known for producing a wide range of chemicals, including plastics and agricultural products. The company has faced lawsuits and fines for environmental pollution and health impacts
2. **DuPont**: A major player in the chemical industry, producing everything from Teflon to Kevlar. DuPont has been involved in legal battles over pollution and health issues related to perfluorooctanoic acid (PFOA)
3. **BASF**: The world's largest chemical producer, involved in the production of chemicals, plastics, and agricultural products. BASF has faced criticism for its environmental impact, including greenhouse gas emissions and water pollution
4. **ExxonMobil Chemical**: A division of ExxonMobil, producing petrochemicals and plastics. The company has been linked to significant environmental pollution, including oil spills and air pollution
5. **Bayer**: Known for pharmaceuticals and agricultural chemicals. Bayer has faced legal challenges related to the health impacts of its products, such as glyphosate, a herbicide linked to cancer
6. **China National Chemical Corporation (ChemChina)**: This state-owned enterprise is one of the largest chemical companies in China. It has been involved in various environmental incidents, including water and soil contamination from pesticide production
7. **Sinopec**: Known for its petrochemical production, Sinopec has faced criticism for its air and water pollution. The company has been linked to several oil spills and emissions of hazardous pollutants
8. **China Petroleum & Chemical Corporation (CPC)**: Another major player in the petrochemical industry, CPC has been associated with significant greenhouse gas emissions and water pollution
9. **Yunnan Yuntianhua Co., Ltd.**: This company, involved in phosphate fertilizer production, has been linked to severe water pollution incidents, affecting local communities and ecosystems
10. **…**

- These examples highlight the need for stringent regulations and sustainable practices to mitigate the negative impacts of the chemical industry on both the environment and human health.

10 chemicals of public health concern

Raw Materials Extraction

- Essential for product manufacturing.
- The extraction of raw materials can involve mining, drilling, and harvesting.
- Mining techniques vary, including open-pit mining, underground mining, and dredging.
- These activities can have significant environmental and human health consequences.
- Understanding the full lifecycle of materials is crucial for sustainability.

Legacy: abandoned mine impacts in Pennsylvania's Appalachia - Uneven Earth

- Deforestation and habitat loss from mining operations.
- Soil erosion and sedimentation affecting nearby water sources.
- Water contamination due to the release of chemicals like mercury and cyanide.
- Air pollution from dust and emissions from heavy machinery.
- Climate change contributions from the energy-intensive extraction process.

Anthracite mining
Orange water indicates oxygenated water with iron hydroxide dropping out to the bottom of the pool. In the background of both mine pools photos, heavily forested areas can be seen. Before mining, these areas of black waste and orange water were also heavily forested and home to diverse wildlife.

Potential societal / human health impacts of raw materials extraction

- Displacement of communities and destruction of livelihoods.
- Health and safety risks for workers in hazardous conditions.
- Social conflicts due to unequal distribution of mining benefits.
- Local economies often becoming dependent on the mining industry.
- Human rights violations, such as child labor and exploitation.
- Exposure to hazardous chemicals such as arsenic, mercury, and lead.
- Respiratory diseases caused by inhaling dust and particulate matter.
- Increased risk of cancers and neurological disorders from toxic exposure.
- Accidental deaths and injuries in mining and extraction sites.
- Long-term health impacts for surrounding populations due to contamination.

Improving the climate impact of raw material sourcing — European Environment Agency

In the EU, non-energy, non-agricultural raw materials, although a small subset of all raw materials and natural resources, account for 18 % of GHG emissions associated with EU consumption

Raw materials extraction could rise by 60% by 2060

- Hard to abate
  - The global steel industry accounts for 7% of CO2e emissions annually.

Fact sheet

Steel and raw materials

In 2021, it is estimated that the global steel industry used about 2.3 billion tonnes of iron ore, 1.1 billion tonnes of metallurgical coal and 680 million tonnes (Mt) of recycled steel to produce 1.95 billion tonnes of crude steel[1].

- Critical materials
  - 71% of all transition mineral mines are in ecosystems that are significant for the preservation of biodiversity and the provision of ecosystem services that benefit society on a local and global scale
  - 16% of the world's land-based critical mineral mines, deposits and districts are located in areas already facing high or extremely high levels of water stress.
  - This evaporation method uses up to half a million gallons of brine water to extract one ton of lithium.

Aerial view of lithium fields in Chile's Atacama desert. South America's "lithium triangle," spanning parts of Chile, Argentina and Bolivia, supplies half of the world's lithium. Photo by Freedom_wanted/Shutterstock

(1) New Messages!

Steel Climate Impact - An International Benchmarking of Energy and CO2 Intensities — Global Efficiency Intelligence

Fact-sheet-raw-materials-2023-1.pdf

How Critical Minerals Mining Affects Water | World Resources Institute

Extraction of raw materials could rise 60% by 2060 – and making mining 'greener' won't stop the damage

Mining and water contamination

- Acid mine drainage occurs when sulfide minerals are exposed to air and water, creating sulfuric acid.
- Heavy metals like mercury and arsenic can leach into local water supplies, affecting aquatic life.
- Sedimentation from mining can clog rivers and lakes, impacting water quality.
- Contaminants can enter the food chain, affecting human populations relying on water for drinking and agriculture.
- Solutions include water treatment technologies and responsible mining practices to reduce contamination.

Metal-mining pollution impacts 23 million people worldwide

BBC

Home News Sport Business Innovation Culture Arts Travel Earth Video Live

Metal-mining pollution impacts 23 million people worldwide

22 September 2023

Share Save

Victoria Gill
Science correspondent, BBC News

An aerial view of a tailings dam storing waste from a copper-mining operation in Chile

At least 23 million people around the world live on flood-plains contaminated by potentially harmful concentrations of toxic waste from metal-mining activity, according to a study.

UK scientists mapped the world's 22,609 active and 159,735 abandoned metal mines and calculated the extent of pollution from them.

Chemicals can leach from mining operations into soil and waterways.

Mining and water contamination

- Estimated 23 million people live on floodplains affected by potentially hazardous concentrations of toxic waste derived from historical and/or active up-stream mining activity.
  - Incomplete reporting of mine locations most notably within China, India, and Russia, and artisanal mining on river systems in the global south.
- While effective recycling processes and use of non-mined materials remain underdeveloped, the energy transition will increase demand for mined commodities.
- Risk of increased incidence of harmful impacts on people, environments and economies.
- Need responsible mining, to acknowledge the harm that mining causes, and to raise awareness of the urgent need for mining companies and regulators to take stronger action to prevent such negative impacts and more actively support responsible mineral supply chains.


Science

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HOME > SCIENCE > VOL. 381, NO. 6664 > IMPACTS OF METAL MINING ON RIVER SYSTEMS: A GLOBAL ASSESSMENT

RESEARCH ARTICLE | MINING IMPACTS

Impacts of metal mining on river systems: a global assessment

M. G. MACKLIN, C. J. THOMAS, A. MUDBHATKAL, P. A. BREWER, K. A. HUDSON-EDWARDS, J. LEWIN, P. SCUSSOLINI, D. EILANDER, A. LECHNER, [...], AND K. R. MANGALAA +3 authors Authors Info & Affiliations

SCIENCE • 21 Sep 2023 • Vol 381, Issue 6664 • pp. 1345-1350 • DOI: 10.1126/science.adg6704

Impacts of metal mining on river systems: a global assessment | Science

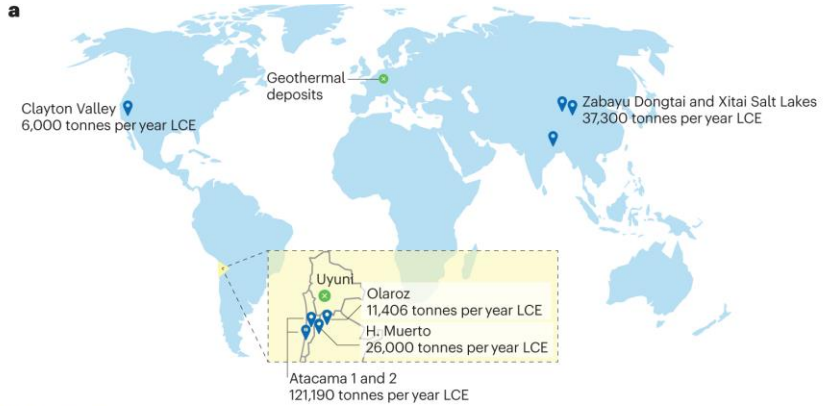
RMF_Harmful_Impacts_Report

Lithium extraction

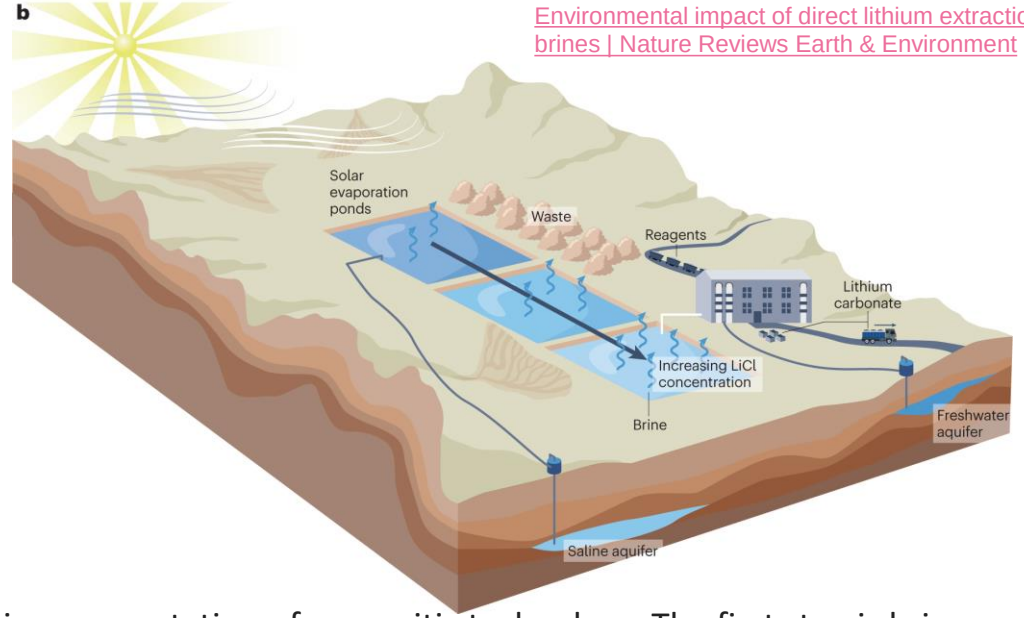
Lithium mining threatens the water and culture of natives in South America

- Direct Lithium Extraction (DLE) is a groundbreaking approach that revolutionizes lithium extraction.
- Unlike conventional methods, which rely on evaporation and mineral concentration, DLE involves the selective extraction of lithium ions directly from lithium-rich solutions.
- This method bypasses the need for evaporation ponds, allowing for faster extraction rates, reduced water consumption, and minimized environmental impact.
- DLE technologies utilize specialized adsorbent materials, membranes, or solvent extraction processes to capture lithium ions selectively.
- By targeting lithium specifically, DLE methods minimize impurities and enable the production of high-purity lithium compounds, which can be used directly in battery manufacturing.
- This efficiency not only reduces production costs but also lowers the overall environmental footprint of lithium extraction.

Zero-Carbon Lithium Compounds - Lithium Harvest



Wakeman

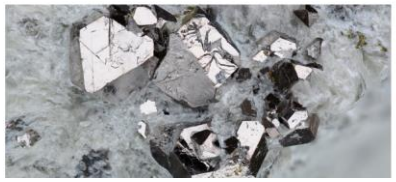


Environmental impact of direct lithium extraction from brines | Nature Reviews Earth & Environment

Schematic representation of evaporitic technology. The first step is brine pumping from underground reservoirs. Brines are poured into large shallow open air ponds, where over 90% of the original water content is lost via evaporation accelerated by solar radiation and wind. LiCl concentration increases gradually and salts from other cations crystallize in the ponds as saturation is reached. Concentrated brines then enter a refining plant for crystallization of the final product (usually lithium carbonate). Fresh water and chemicals are used at several steps of processing.

Cobalt extraction

DR Congo's faltering fight against illegal cobalt mines | AFP



Miners at a cobalt cleaning site in DRC wash ore in water

Responsible Minerals Initiative: Cobalt Due Diligence in the DRC

- The Democratic Republic of the Congo (DRC) is the world's largest producer of cobalt and has approximately half of the world's cobalt reserves.
- Cobalt is used in lithium-ion batteries, a key part of electric vehicles and electronic devices, among other uses.
- Demand for cobalt has risen significantly over the years as cobalt is considered a critical mineral for the energy transition.
- Cobalt is extracted through mechanized (large-scale mining) and artisanal (ASM) mining operations in the DRC

Multiple reports and stakeholders have highlighted concerns over the social and environmental impacts of cobalt mining, including child labor, unsafe working conditions, community resettlement, and corruption allegations.

- Toxic dumping is devastating landscapes, polluting water, and contaminating crops. High concentrations of cobalt have even been linked to the death of crops and worms, which are vital for soil fertility.
- "In this stream, the fish vanished long ago, killed by acids and waste from the mines," says Congo resident Heritier Maloba, staring into the murky waters of his childhood fishing hole. This is a similar story across the cobalt regions of Congo.
- A study that collected fish from Tshangalale lake, which is adjacent to mining towns, found that the fish were contaminated with prominent levels of cobalt. This contamination is easily spread to humans through the consumption of fish or drinking of the lake's water. Classified as a 'possible' carcinogen, and being a radioactive element, this also poses an immense hazard to human health.
- A further environmental impact of cobalt mining in Congo is the hazy air surrounding the mines, full of dust and grit, and toxic to breathe. Studies have shown that the risk of birth defects, such as limb abnormalities and spina bifida, greatly increased when a parent worked in a cobalt mine, linked to high levels of toxic pollution caused by the extraction of cobalt.

Cobalt RMI_Cobalt_Brochure_0923.pdf The Environmental Impacts of Cobalt Mining in Congo | Earth.Org

bility-Cobalt

- Child labor in artisanal and small-scale mining
- Environmental impact of mining residues on water and soil
- Violation of human rights through armed attacks by public or private security forces, including forced displacement, sexual assault, arson and abuse
- Corruption and weak rule of law in specific countries

Catalog of measures.

- In order to promote the procurement of raw materials from responsible sources, the BMW Group relies, among other things, on the direct purchase of cobalt
- Involvement in the on-site **Cobalt for Development** Project
- Establishment of a closed material cycle to reuse the raw materials nickel, lithium and cobalt from **high-voltage batteries in China**
- Research and development to increase the secondary raw material quota

Initiatives.

- Initiative for Responsible Mining Assurance (IRMA): Collaboration on the further development of the IRMA standard
- Battery Pass Consortium: Collaboration on the development of a battery pass based on the new EU Battery Regulation
- Membership of the Global Battery Alliance: Building a sustainable and responsible value chain for batteries

Steel: iron ore extraction

- Iron ore is a natural mineral deposit that contains iron in various concentrations and is the raw material for the production of steel.
- It is the world's most extracted metal and the basis for the production of steel, one of the biggest commodities worldwide.
- More than 86% percent of iron ore is extracted from Australia, Brazil, China, India, Russia and South Africa.
- All raw materials are ultimately confined to these locations of supply.
- Method of Extraction: Mostly open-pit mining, also known as surface mining.

Key Impacts

1 **Habitat destruction.**

Open-pit mining requires large surface areas and necessitates the removal of topsoil and vegetation to access materials that lie underneath. Therefore, existing biodiversity, such as habitats of animal and plant species, will be destroyed during the time of material extraction. Mining impacts highly depend on existing conditions on-site before an intervention.

2 **Associated infrastructure.**

Because iron mines are frequently located in remote and ecologically diverse areas, mining requires access to these sites and the energy infrastructure to support mining operations. Linear infrastructure such as roads, power lines, and rail lines can lead to habitat fragmentation and impacts along their route. Making these regions more accessible in turn leads to increased traffic and settlement, with all its associated impacts on pollution, resource use, and waste.

3 **Water use.**

Ore mining and processing require large quantities of freshwater. Many mines are located in areas of water stress, exacerbating the local scarcity even further.

4 **Contamination and pollution of soil and water.**

Large quantities of water can become contaminated with environmentally harmful tailings being stored in dams, which can present a severe risk in case of dam failure. Dust and particulate matter released during mining can have adverse effects on the respiratory systems of nearby humans and animals.

Tailings are the waste materials that remain after the extraction of valuable minerals from an ore during the mining process. They are typically in the form of a fine-grained, slurry-like substance and are stored in large impoundments or tailings dams. Tailings contain residual minerals, chemicals, and other by-products of the mining process, such as crushed rocks and processing chemicals.

Understanding ResponsibleSteel: How does it work? - YouTube

Environmental Impacts of Iron Ore Mining | UKGBC

We're shaping a more responsible steel industry | ResponsibleSteel

Aluminum: bauxite

- Open-pit mining, also known as surface mining

1 Habitat destruction

Many bauxite deposits and mines are often located close to, or even in protected areas and indigenous lands, and often in tropical forests. These areas tend to contain ecosystems of particular importance, such as the Amazon rainforest in Brazil or the Guinean rainforest. Open-pit mining requires large surface areas and necessitates the removal of topsoil and vegetation to access materials that lie underneath. Therefore, existing biodiversity, such as habitats of animal and plant species, will be destroyed during the time of material extraction. Mining impacts highly depend on existing conditions on-site before an intervention.

2 Associated infrastructure

Because bauxite mines are frequently located in remote and ecologically diverse areas, mining requires access to these sites and the energy infrastructure to support mining operations. Linear infrastructure such as roads, power lines, and rail lines can lead to habitat fragmentation and impacts along their route. Making these regions more accessible in turn leads to increased traffic and settlement, with all its associated impacts on pollution, resource use, and waste.

3 Water use

Ore mining and processing require large quantities of freshwater. Many mines are located in areas of water stress, exacerbating the local scarcity even further.

4 Contamination and pollution of soil and water

Large quantities of bauxite tailings, also known as red mud, are stored in open-air dams, requiring large areas of land. Due to their alkalinity and salinity, bauxite tailings present a severe threat to wildlife and ecosystems. In the event of dam failures, these tailings spread over vast areas with hazardous ecological impacts, as demonstrated by many past incidents. In addition, heavy metals present in red mud can accumulate in the food chain. Dust and particulate matter released during mining can have adverse effects on the respiratory systems of nearby humans and animals.

Wakeman

Producing Endless Possibilities: Alcoa Global Bauxite

Solutions

•**Aluminium recycling**. Recycling of aluminium offers a great opportunity as it can be recycled infinitely with no loss of quality. Currently, the share of secondary aluminium production from scrap is around 35% of the total production according to data from the International Aluminium Institute. Global collection rates for aluminium are currently over 95% for manufacturing scrap and around 75% for end-of-life scrap. This should be increased by better recycling infrastructure such as extended producer responsibility schemes.

IAI updates Sustainable Bauxite Mining Guidelines - International Aluminium Institute

Environmental Impacts of Aluminium & Bauxite Mining | UKGBC

ASI Home | Aluminium Stewardship Initiative

Aluminum: supply chain impacts

Global physical trade networks for aluminium and EU-28 position

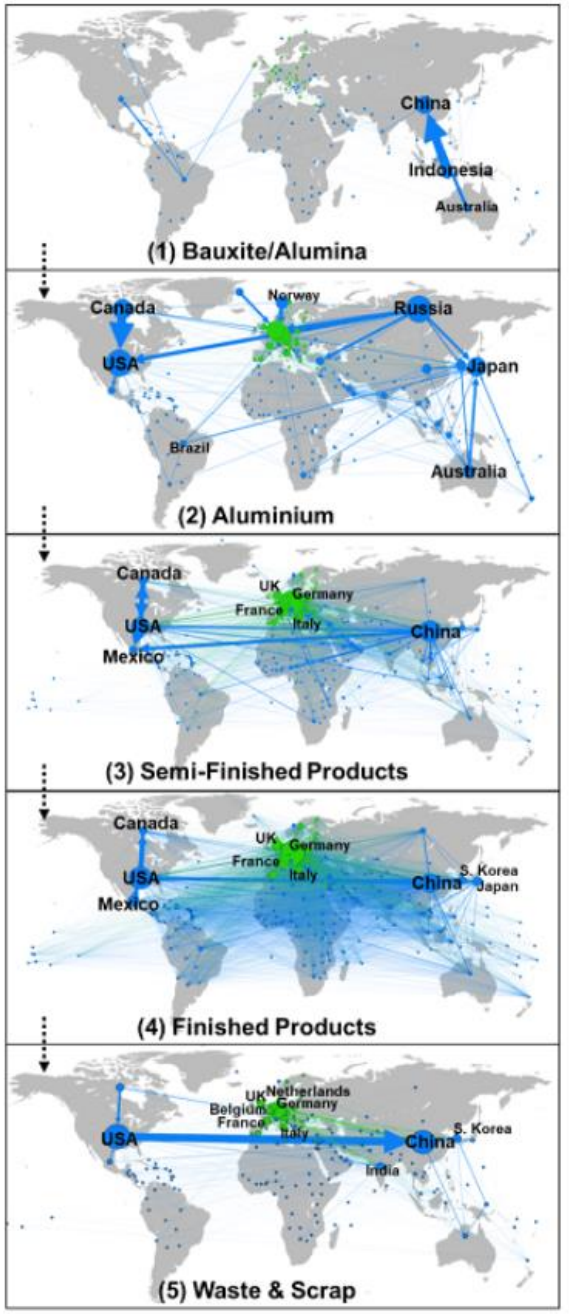
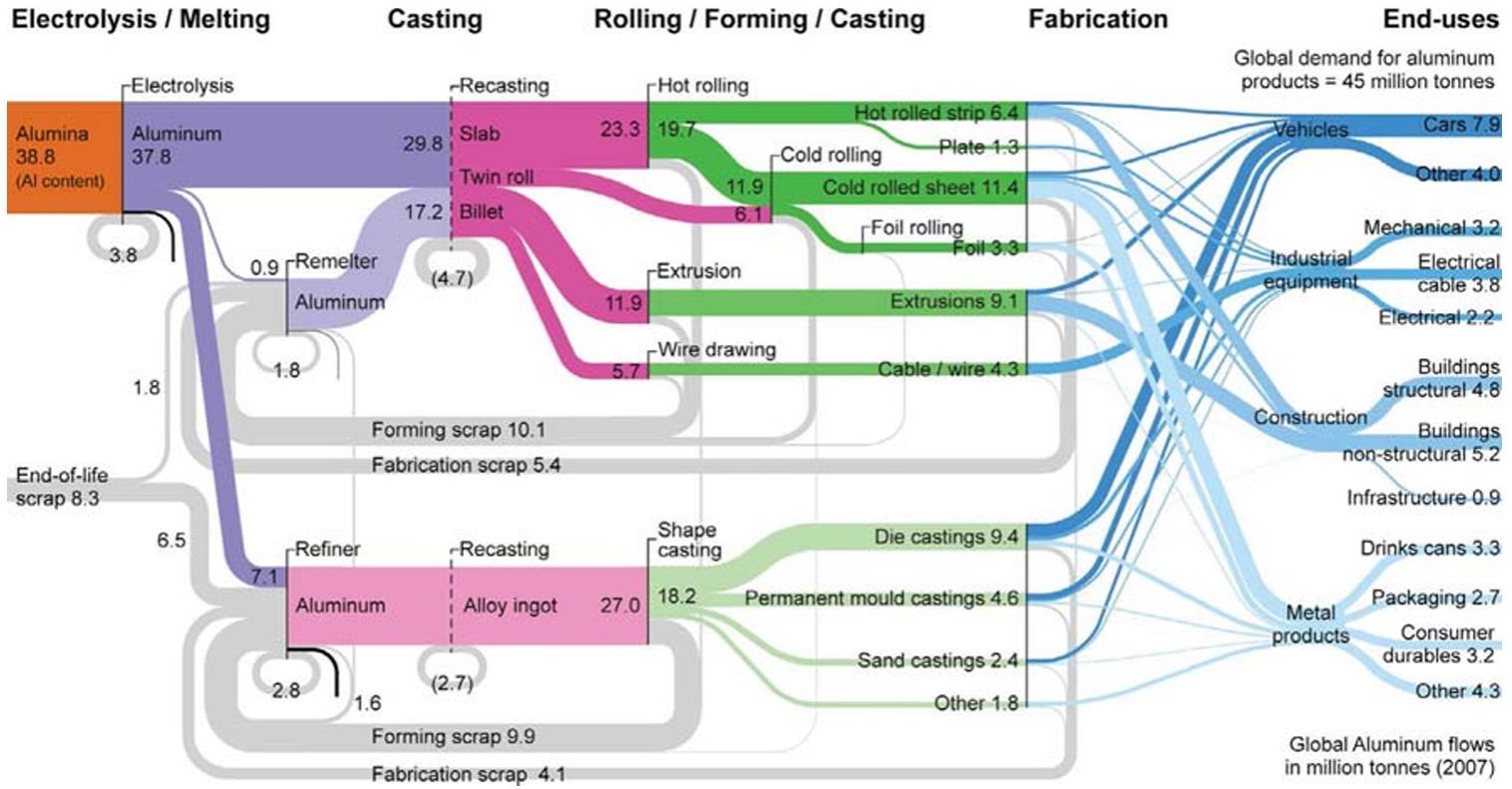


Figure 7: Global material flows across the value chain for aluminium (world, 2007)[33].



Scoreboard2018.Introduction.pdf

Copper

1. **Water Pollution**: Mining activities can lead to the contamination of water sources with heavy metals and chemicals used in the extraction process
2. **Deforestation**: Large areas of forest are often cleared to make way for mining operations, leading to habitat destruction and loss of biodiversity
3. **Land Degradation**: The physical alteration of the land, including the creation of large open pits and waste piles, can lead to soil erosion and loss of arable land
4. **Air Pollution**: Dust and emissions from mining operations and the transportation of ore can degrade air quality and contribute to respiratory problems in nearby communities
5. **Acid Mine Drainage**: Sulfide minerals in the ore can react with water and oxygen to produce sulfuric acid, which can leach into waterways and harm aquatic life
6. **Waste Generation**: The extraction and processing of copper generate large amounts of waste rock and tailings, which can contain harmful substances

Inside one of the largest copper mines in the world
Oyu Tolgoi | Global

https://youtu.be/0fBrOULfyyA

RioTinto

About Products Operations Sustainability Invest News

How Nuton works

At Nuton's core is a biological leach process that transforms copper-bearing rock or mine waste into 99% pure copper cathode.

Our leaching process starts by creating a heap – a very large pile of crushed rock. Depending on the site, that could be newly mined ore or previously mined rock that has been discarded as waste.

Added to the heap is a carefully cultivated culture of micro-organisms – the natural catalyst of our technology. Once added, they multiply, harnessing energy from the minerals in the rock to grow and concentrate the copper.

To support the microorganisms, we aerate the heap and add acidified water. By creating favourable conditions for microorganism activity, we accelerate the copper leached from chalcopyrite in the heap material, enabling unparalleled copper recovery.

Nuton: A better way to produce copper | Global

RioTinto-Copper | Global

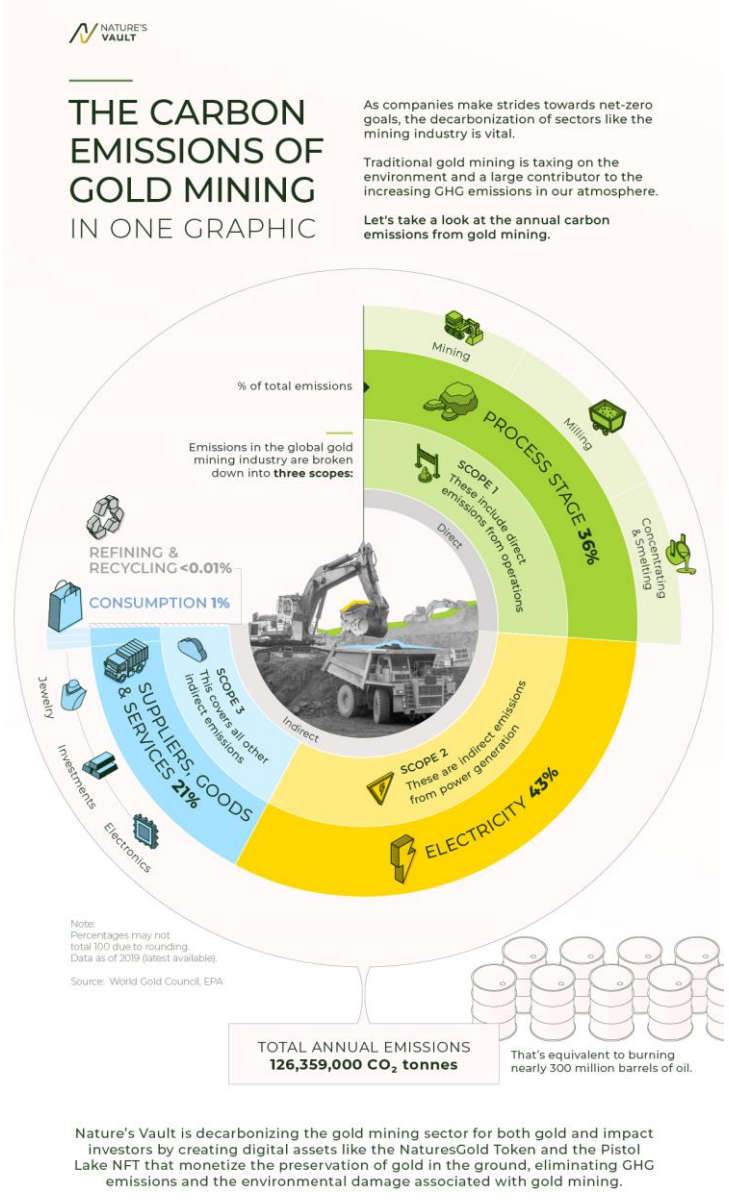
https://youtu.be/V5aDnIfBCKA

https://enviroliteracy.org/does-copper-mining-affect-the-environment/

Gold

- Gold mining has several significant environmental impacts:

1. **Water Pollution**: The use of toxic chemicals like cyanide and mercury in gold extraction can contaminate water sources, harming aquatic life and potentially affecting human health1
2. **Habitat Destruction**: Large-scale mining operations often lead to deforestation and the destruction of natural habitats, which can result in the loss of biodiversity
3. **Soil Erosion**: The removal of large amounts of earth and rock can lead to soil erosion, which can degrade land and make it unsuitable for agriculture
4. **Air Pollution**: Dust and emissions from mining activities can degrade air quality, contributing to respiratory problems in nearby communities
5. **Acid Mine Drainage**: Exposure of sulfide minerals to air and water can produce sulfuric acid, which can leach into waterways and create highly acidic conditions that are harmful to aquatic ecosystems
6. **Waste Generation**: Gold mining generates large amounts of waste rock and tailings, which can contain harmful substances and pose long-term environmental risks



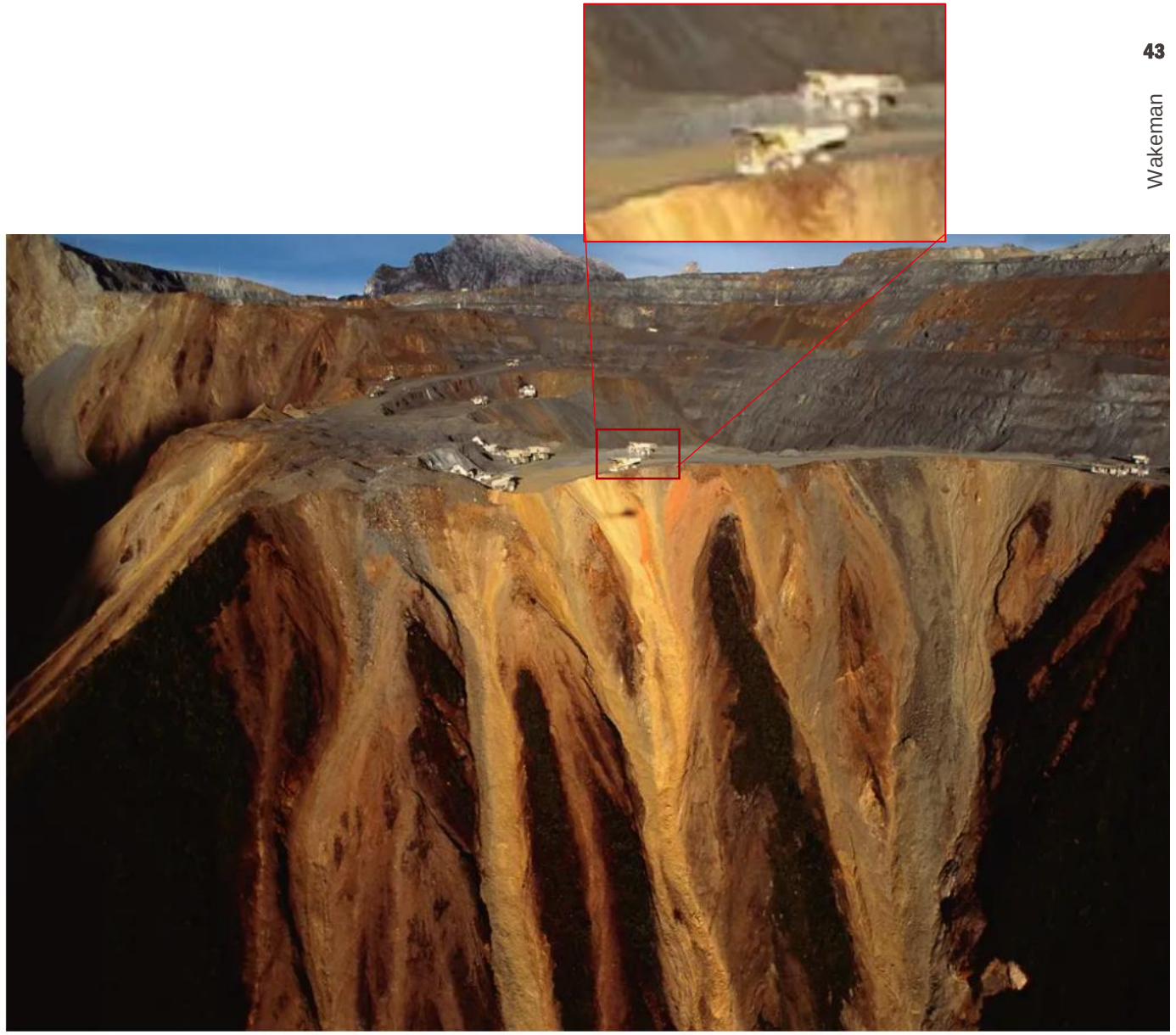
Environmental Impacts of Gold Mining - Earthworks

2018_12_07_WWF Watch and Jewellery Report 2018_final_e_0.pdf

The Carbon Emissions of Gold Mining

Gold mines

- The majority of the world's gold is extracted from open pit mines, where huge volumes of earth are scoured away and processed for trace elements.
- Studies show that, to produce a measurable quantity of raw gold to make a single ring, 20 tons of rock and soil are dislodged and discarded.
- Much of this waste carries mercury and cyanide, which are used to extract the gold from the rock.
- The resulting erosion clogs streams and rivers and can eventually contaminate marine ecosystems far downstream of the mine site.
- Exposing the deep earth to air and water also causes chemical reactions that produce sulfuric acid, which can leak into drainage systems.
- Gold mining also affects air quality, which releases hundreds of tons of airborne elemental mercury every year.
- Communities are displaced, contaminated workers are hurt, and the pristine environment is destroyed.

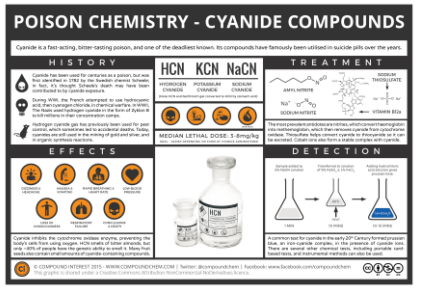


The 13,000-foot high Grasberg mine contains the largest single gold reserve in the world, and the largest copper deposit as well. © George Steinmetz/Corbis

The Environmental Disaster That is the Gold Industry | Smithsonian

11 Environmental Impacts of Gold Mining - Environment Go!

Gold & cyanide



Use of Cyanide in Gold Mining

1. **Leaching Process**:
    1. **Heap Leaching**: Crushed ore is piled into large heaps and sprayed with a cyanide solution. The cyanide dissolves the gold, which is then collected from the bottom of the heap1
    2. **Vat (or Tank) Leaching**: Ore is mixed with a cyanide solution in large tanks. This method is more controlled and reduces the risk of spills
2. **Chemical Reaction**: Cyanide forms a water-soluble complex with gold, allowing it to be separated from the ore. This process is known as gold cyanidation or the MacArthur-Forrest process

Environmental and Health Risks

1. **Toxicity**: Cyanide is highly toxic and can cause severe environmental damage if not managed properly. Spills and leaks can contaminate water sources, leading to fish kills and poisoning of drinking water
2. **Accidents**: There have been several notable accidents involving cyanide spills, such as the 2000 Baia Mare cyanide spill in Romania, which caused extensive environmental damage

Waste Management: The waste products from cyanide leaching, known as tailings, are stored in large impoundments. These can fail and release toxic substances into the environment

Safety Measures

1. **Alkaline Conditions**: Maintaining an alkaline pH level (above 10.5) is crucial to mitigate the risks associated with cyanide use. Lime is often added to ensure the pH remains at safe levels
2. **Regulations and Monitoring**: Strict regulations and continuous monitoring are essential to prevent environmental contamination and ensure the safe use of cyanide in mining operations

Despite its risks, cyanide remains a widely used method for gold extraction due to its effectiveness. However, ongoing efforts to develop safer and more sustainable alternatives are crucial for minimizing its environmental impact.

Cyanide Use in Gold Mining

Today's hardrock mining industry too often spills cyanide, endangering the environment, wildlife and humans.

Yukon officials grilled over possible cyanide contamination after mining landslide - YouTube

Cyanide Use in Gold Mining - Earthworks

Cyanide free gold mining

- Cyanide-free sustainable gold mining is an innovative approach aimed at reducing the environmental impact of traditional gold extraction methods.
- One notable development in this field is the **CLEVR Process** by Dundee Sustainable Technologies (DST).
- This process uses a mild bleach solution instead of cyanide to extract gold, significantly reducing environmental risks
- The CLEVR Process operates in a closed-loop system, which means all chemicals are recycled, and it can achieve gold extraction yields of over 90%
- This method not only minimizes the use of toxic materials but also enhances efficiency by reducing leaching time from over 24 hours to about 2 hours

Dundee Sustainable Technologies partners with top gold miners on groundbreaking non-cyanide mineral extraction

Provided By Dundee Sustainable Technologies

February 25, 2025

Dundee Sustainable Technologies (DST) is forging partnerships with top gold miners as it commercializes its novel metallurgical processes, which have been proven to reduce leaching time and extract more gold without using toxic materials such as cyanide.

DST's Plant & Technical Facilities in Thetford Mines, Canada

Dundee Sustainable Technologies partners with top gold miners on groundbreaking non-cyanide mineral extraction - MINING.COM

Gold and Switzerland?

- "Switzerland has a particularly strong relationship with gold: Not only is 50 % – 70 % of the world's gold refined in Switzerland, but Swiss banks also play a crucial role in marketing bullion.
- Switzerland is also a primary hub for upmarket jewellery and watchmaking.
- Despite their reliance on this precious metal, the awareness of watchmakers, jewellers and end consumers of the risks involved with the gold supply chain is, however, still very low."

1. EXECUTIVE SUMMARY

Switzerland is a central hub on many levels along the global gold supply chain. Of the seven large global gold refineries, four are in Switzerland. Swiss gold is a trademark that enjoys a great deal of trust among customers worldwide and is therefore highly regarded and recognised. Moreover, Swiss banks play a crucial role in the investment of gold and the Swiss jewellery and watch markets are key end-users of gold as well.

Watches, jewellery, and investments are by far the most important application sectors for gold and in all three of these sectors, Switzerland is among the world leaders. While the watch and jewellery sectors have the highest total consumption of gold, the demand from the investment sector has been growing lately maintaining the need for new gold and mining operations.

In 2018, WWF Switzerland published a study where the biggest Swiss watch companies were ranked based on their environmental performance. This rating demonstrated that most companies were not able to trace back along their supply chain to understand where the raw materials for their products were sourced. This new study focuses not on a ranking of individual companies but instead on providing a more in-depth investigation of the environmental and social impact of gold as well as Switzerland's role as one of the major global gold hubs; it thereby highlights the lack of transparency in the gold supply chain.

The environmental impacts and social challenges along the supply chain are systematically outlined. The key findings of the study are:

1 TONNE OF GOLD → 100 000 TONNES OF WASTE ROCK

– To extract 1 tonne of gold, an average of 100 000 tonnes of waste rock is produced. 1 000 kg of soil must be moved and processed to produce a 10 g gold ring.

1 KG OF GOLD → 12 500 KG OF CO_2

– The production of 1 kg of gold leads to the emission of 12 500 kg of CO_2 equivalent. This equates to approximately 42.25 million tonnes of CO_2 equivalent for all gold production globally in 2019, which is nearly three times the amount of all transportation-related emissions in Switzerland.

838 TONNES OF MERCURY EMISSIONS IN THE AIR

– In 2015, artisanal and small-scale gold mining (ASGM) mercury emissions to air amounted to ca. 838 tonnes, the single largest source of anthropogenic mercury emissions, at almost 38 % of the worldwide total. The mercury used on a large scale in ASGM poses significant health risks to workers and residents either directly or through the food chains.

ASGM FROM SUB-SAHARAN AFRICA & SOUTH AMERICA

– Sub-Saharan Africa and South America are the main regions for ASGM. Between 2010 and 2015, South America increased its mercury emissions by 163 %. This goes hand in hand with an increase in ASGM in the Amazon.

DAMAGE TO SOIL, WATER, FLORA & FAUNA

– The study shows in detail how gold mining causes substantial damage to soil, water and flora and fauna.

HARM ON FORESTS WILDLIFE

– Compared to other minerals, gold is by far the raw material most often mined in forest areas. These forests are often particularly valuable ecologically, which greatly increases the potential impact of gold mining on flora and wildlife.

LARGE-SCALE & SMALL-SCALE GOLD MINING BOTH CAUSE ENVIRONMENTAL PROBLEMS

– Analysis shows that large-scale gold mining (LSGM), which accounts for about 80 % of global gold mine production, also causes environmental problems. In general, LSGM impacts tend to be locally concentrated and massive as deposits are mined over longer periods of time. Due to the scale of the operations, impacts following accidents are often devastating. Tailings dam breaks resulted in some of the biggest environmental catastrophes in history. Hazardous substances contained in processing reagents as well as heavy metals and acid mine drainage (AMD) are crucial issues in LSGM.

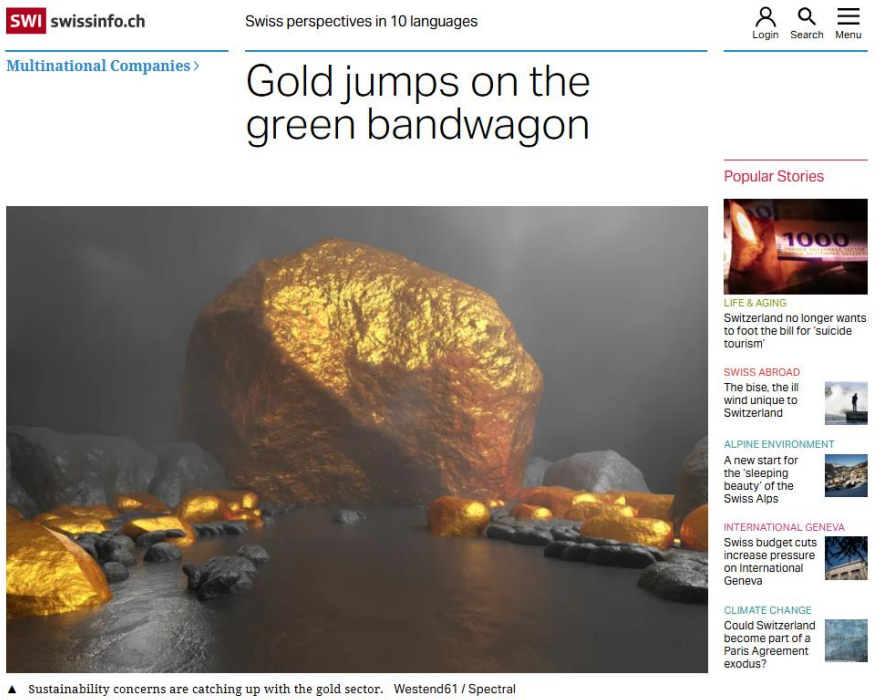
6

Wakeman

[2021_11_The_Impact_of_Gold_WWF.pdf]

Carbon free gold?

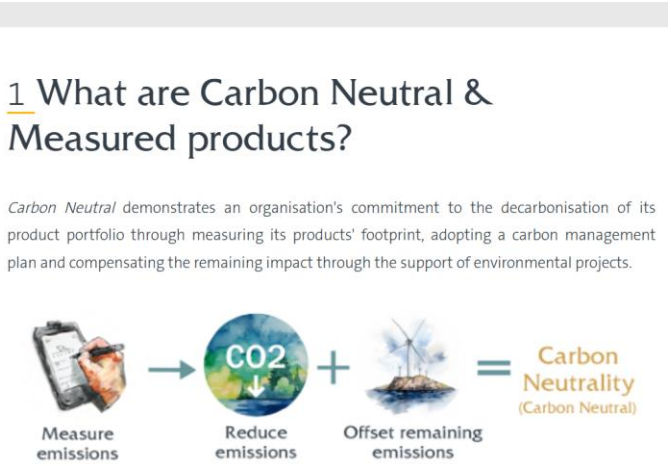
- 1kg of gold creates 12,500kg of CO2 emissions
- When all stages and processes are combined, producing 1kg of gold requires 208,000 megajoules of energy, compared to 3,280 for silver of 53.7 megajoules for copper
- MKS PAMP is currently developing a carbon-neutral minted gold bar.



Carbon Verified Products | MKS PAMP
The Journey - Environmental Responsibility
Gold jumps on the green bandwagon - SWI swissinfo.ch

Carbon offsets?

- To offset the carbon emissions, it is supporting carbon avoidance projects in countries that are key to the company.
- These include an Indian Solar Photovoltaic project, a renewable energy project in Brazil; and a hydropower project in the Ivory Coast.
- The projects are certified by Verra, one of the many players offering quality assurance in the booming voluntary carbon offsets markets.



Q: if everyone offsets their emission but does not reduce them, how can we achieve NetZero?

The Guardian

Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows

Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows | Carbon offsetting | The Guardian

Verra Response to Guardian Article on Carbon Offsets

18 JANUARY 2023

Verra Response to Guardian Article on Carbon Offsets - Verra

Johan Rockström, the director of the Potsdam Institute for Climate Impact Research and chief scientist at Conservation International, which manages a number of carbon offsetting projects, says that offsetting can be valuable but only if companies are already cutting their carbon emissions by at least half each decade, from now to reaching net zero in 2050. They can buy offsets as an additional effort, beyond those reductions, but the offsets cannot be used as a substitute for those stringent emission-reduction requirements.

Gold jumps on the green bandwagon - SWI swissinfo.ch

Social Justice and Mining

- Mining operations often disproportionately impact marginalized communities, leading to social inequalities.
- Indigenous peoples are frequently displaced from their land for mining projects.
- Workers in mining industries, especially in developing countries, often face exploitation and poor working conditions.
- Social justice concerns include ensuring fair wages, safety standards, and protection for local communities.
- Sustainable mining practices must include transparent communication, fair compensation, and respect for human rights.

•Transition minerals tracker

Over two-thirds of all recorded allegations include **just 12 companies**, which are among the largest and most well-established of the extractive sector. This includes Grupo México, Codelco, BHP, Anglo American and Glencore.

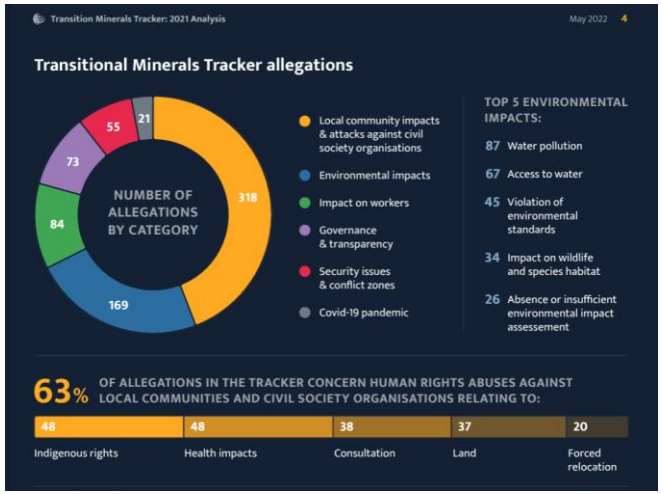
Transition Minerals Tracker: Global analysis of human rights in the energy transition

Transition_Minerals_Tracker_Global_analysis.pdf

Transition Minerals Tracker - Business & Human Rights Resource Centre

- **495 allegations** of human rights abuse from 2010 to 2021.
- **61 new allegations in 2021**.
- One-third of allegations represent **attacks against HRDs**, making this the number one impact recorded in the Tracker, followed by **water pollution**.
- One-third of attacks against HRDs are against **Indigenous peoples**.

copper and cobalt mines exploited by the Glencore-owned firms Kamoto Copper Company (KCC) and Mutanda Mining (MUMI).



SWI swissinfo.ch — Swiss perspectives in 10 languages

Banking & Fintech ›

Glencore accused of environmental pollution in DRC

▲ A hairdresser's salon in front of Glencore's KCC copper mine at Kolwezi in southern DRC © Meinrad Schade

Two Swiss non-governmental groups have accused Swiss-based commodity trader and miner Glencore of continuing to pollute the air and soil around mines near the town of Kolwezi in the south of the Democratic Republic of the Congo (DRC).

November 27, 2018 - 11:20 — 3 minutes

Simon Bradley

swissinfo.ch/sb

According to a report by the Swiss NGOs Bread for All and Catholic Lenten Fund, despite improvements to the water supply and water pollution around Kolwezi, the multinational's due diligence for human rights and the environment remains incomplete.

Glencore accused of environmental pollution in DRC - SWI swissinfo.ch

Distant stakeholders

- Always look at both sides of the discussion
- Look at data, progress in the right direction is to be praised while still increasing ambition levels

GLEN-2023-Sustainability-Report.pdf

Glencore rights record worst in green metals, group says

Bloomberg News | May 4, 2022 | 7:10 am Top Companies Europe Cobalt Copper Lithium Manganese Nickel Zinc

The Mutanda copper-cobalt mine, Democratic Republic of the Congo. Source: YouTube

Glencore Plc has the worst human rights record among miners of metals used in renewable energy, the Business & Human Rights Resource Centre said in a report.

The alleged abuses attributed to all companies range from attacks on activists to violations of environmental laws to forced relocations. Complaints about Glencore's mines accounted for 64 out of the 495 allegations tracked by the London-based group between 2010 and 2021.

Glencore rights record worst in green metals, group says - MINING.COM

Meeting our targets

Our policy architecture developed in 2021, which included revised and new Policies and Standards, has strengthened our governance for overseeing the achievement of our Group health, safety, environment, social performance and human rights (HSEC&HR) targets.

In 2023, we continued to roll out these Policies and Standards through a series of workshops and training programmes. Our industrial assets undertook gap assessments against the revised HSEC&HR Standards, reporting substantial compliance to these Standards on average across all of them as at the end of 2023. Where gaps were identified, improvement actions have been developed and are being progressively completed.

Both Group HSEC&HR and our industrial commodity departments review progress against our Group HSEC&HR targets on a monthly or quarterly basis, depending on the target.

Group HSEC&HR targets	2023 progress
Risk management and governance	
Implement a proactive risk-based approach to prevent HSEC&HR incidents.	We continued to implement our Enterprise Risk Management Standard that we launched in 2021. It includes our approach to catastrophic risks and the need to identify and monitor critical controls. Our industrial commodity departments annually present their risk registers and key controls to eliminate or minimise the risks.
No catastrophic tailings storage facility (TSF) dam failures.	We recorded no catastrophic TSF dam failures.
Conformance with Global Industry Standard for Tailings Management (GISTM), in accordance with our International Council on Mining & Metals (ICMM) commitments.	We met the ICMM's 5 August 2023 deadline for GISTM disclosures on TSFs with a 'Very High' and 'Extreme' Consequence Classification and identified areas of improvement to achieve conformance. We are working towards meeting the ICMM's 5 August 2025 deadline for GISTM disclosures on TSFs with all other Consequence Classifications. We will continue to implement the requirements of the GISTM.
Health	
Year-on-year reduction in the number of new occupational disease cases (excluding new cases from legacy exposures).	In 2023, we recorded 162 new occupational disease cases (2022: 101 cases (restated)). The increase reflects the implementation of stronger definitions for occupational disease indicators, which, in turn, supported stronger reporting on this material topic.
Safety	
No work-related (occupational) fatalities[1].	It is with deep sadness that we recorded the loss of four[A] lives at our industrial assets during 2023.
Environment	
15% reduction in our Scope 1, 2 and 3 emissions by the end of 2026 against a restated 2019 baseline.	We recorded 433Mt of Scope 1 and 2 market-based emissions, and Scope 3 emissions (2019 restated: 554Mt). This decrease is largely attributable to the decline of coal production in our operationally controlled industrial assets, which results in lower customer use of our sold coal volumes. For further information see the About our emissions calculations and reporting section in our **2023 Annual Report** (page 53) and the Basis of Reporting 2023.
50% reduction in our Scope 1, 2 and 3 emissions by the end of 2035 against a restated 2019 baseline.	
Ambition of achieving net zero industrial emissions for our Scope 1, 2 and 3 emissions by the end of 2050, subject to a supportive policy environment.	
By 2023, all industrial assets located in water-stressed areas[2] to finalise the assessment of their material water-related risks, setting local targets and implementing actions to reduce impacts and improve performance.	We finalised the assessment of material water-related risks and set local water targets for our industrial assets located in water-stressed areas; our internal water working group assessed these targets and risk assessments. We are implementing actions to reduce impacts and improve performance against these targets.
No major or catastrophic[3] environmental incidents.	We recorded no major or catastrophic environmental incidents[A].
Social performance and human rights	
Do not cause or contribute to incidents resulting in severe[4] human rights impacts.	We did not cause or contribute to incidents resulting in severe human rights impacts.

1. Refer to the Basis of Reporting 2023 for information on how occupational fatalities are recorded.
2. We define water-stressed areas as having a high to extremely high or arid and low water-use baseline water stress, as per the World Resources Institute definitions.
3. Refer to the Basis of Reporting 2023 for information on how major and catastrophic environmental incidents are recorded.
4. Severe is the equivalent of catastrophic and major on Glencore's incident classification scale. For human rights, a catastrophic incident is one with a gross human rights violation or grave systemic human rights impacts and a major incident involves an isolated grave or serious systemic abuse of human rights.

Regulations and Policies in Mining

- Environmental regulations are essential to control the environmental impacts of mining operations.
- Policies like environmental impact assessments (EIAs) and sustainable mining standards help guide mining projects.
- International regulations, such as the Extractive Industries Transparency Initiative (EITI), promote transparency in mining practices.
- Governments can impose fines and penalties for non-compliance with environmental laws.
- Collaboration between governments, businesses, and NGOs can strengthen regulations and enforcement.

Extractive Industries Transparency Initiative | EITI

Anglo American's El Soldado mine faces charges for environmental breaches in Chile

Staff Writer | December 9, 2024 | 4:27 pm News Top Companies Europe Latin America Copper

Anglo American Sur's El Soldado mine in Chile. Image submitted by SMA.

Chile's environmental watchdog has laid three charges against Anglo American (LON: AAL) for environmental breaches at its El Soldado copper mine, located 125 km north of the capital Santiago.

The Superintendency of the Environment (SMA) labelled the charges as "serious," the second of three levels of offenses, and said Anglo American Sur, the local arm of Anglo American, faced the possible revocation of its environmental permit, closure or a fine of more than 12 billion pesos ($12.4 million) if it did not address the issues.

Earth systems impact - mining

- Corporations are responsible for a significant portion of observed impacts on the Earth system, including green- house gas (GHG) emissions, but also water extraction, landuse change and other pressures on nature.
- These nature-related impacts are essential to consider and capture because they have local impacts on a range of ecosystem functions on which companies and economies depend, but they also fundamentally affect our ability to mitigate and adapt to a changing climate.
- Furthermore, climate, land and water interact and affect each other in various ways, such that climate change can be exacerbated by degraded ecosystems, which in turn are dependent on water.
- **Earth systems impact**
  - **CO2e**
  - **Land systems**
  - **Water use**
- **Mining sector case study**
  - 5 largest capitalization mining companies in precious metals
  - 5 largest in non-precious metal mining

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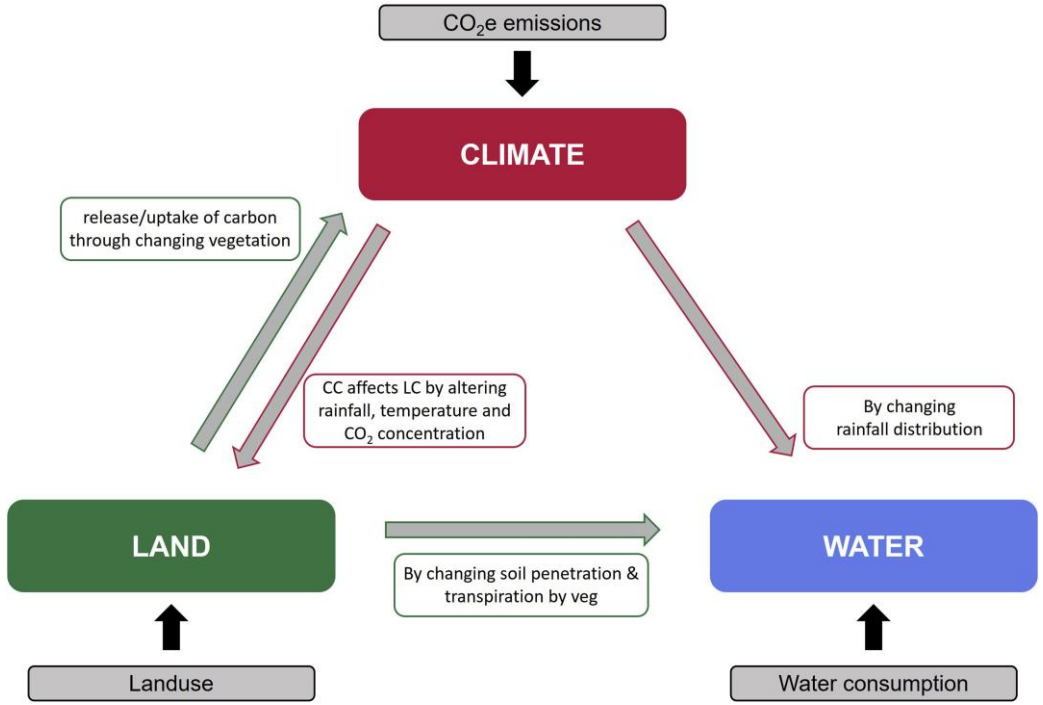
Volume 429, 1 December 2023, 139523

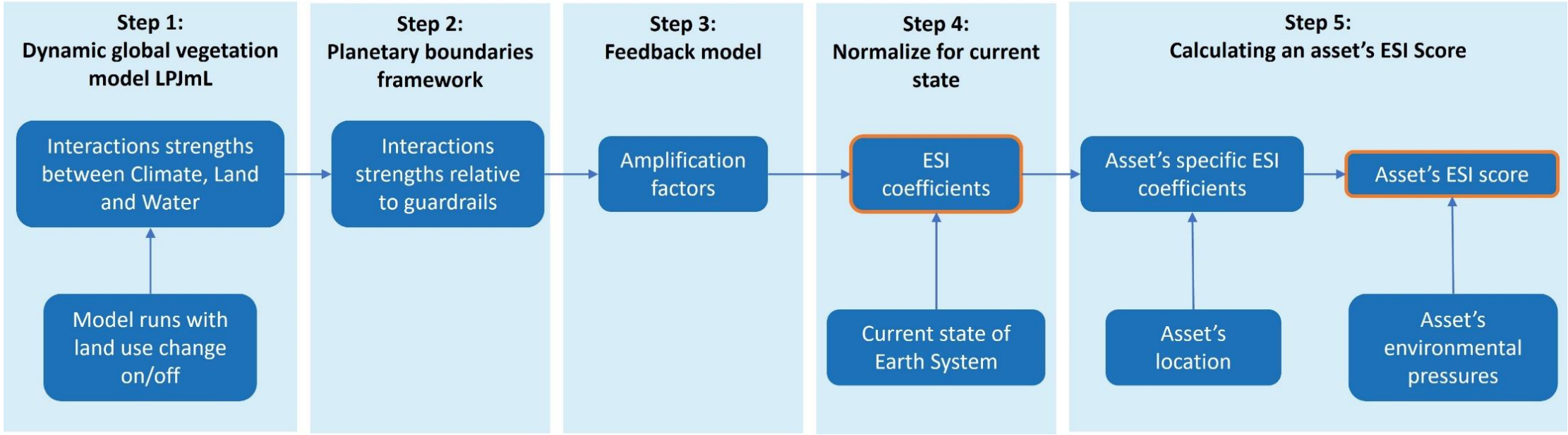
Going beyond carbon: An "Earth system impact" score to better capture corporate and investment impacts on the earth system

Beatrice Crona [a b], Giorgio Parlato [a], Steven Lade [b c], Ingo Fetzer [b], Victor Maus [d e]

Going beyond carbon: An "Earth system impact" score to better capture corporate and investment impacts on the earth system - ScienceDirect



Earth systems impact



- Overview of ESI calculation methodology.

The figure outlines the consecutive methodological steps that comprise the calculation of the Earth System Impact score. Two boxes are highlighted with orange. These represent the ESI coefficients, which are the output from Lade et al (2021) used as the basis for calculations in this study; and the ESI scores for each (mining) asset, which represent the analytical outputs of this paper.

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Earth systems impact - mining

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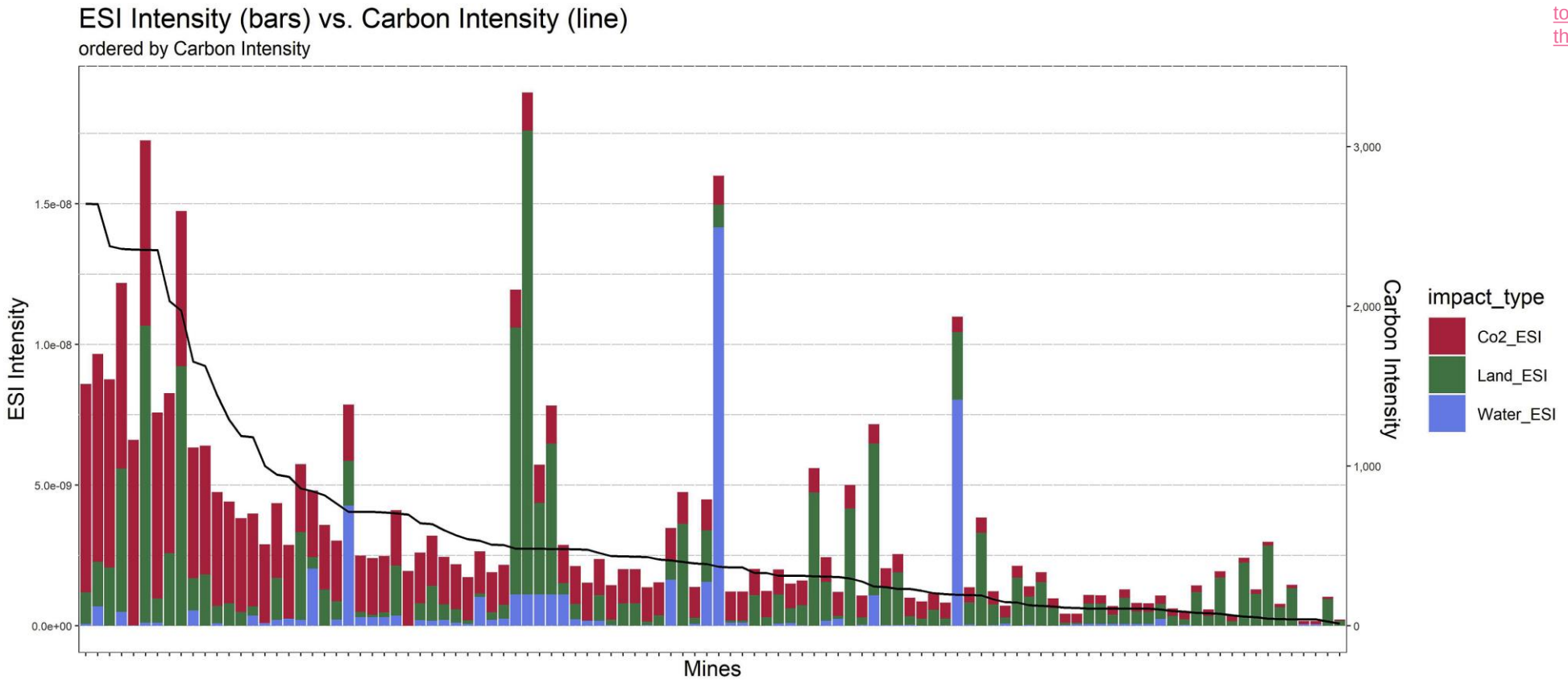

Largest 5 for metal mining (by Market Cap)	Largest 5 for precious metals production (by Market Cap)
1. Rio Tinto Plc	1. Newmont Corporation
2. Vale S.A.	2. Barrick Gold Corporation
3. Anglo American Plc	3. Franco-Nevada Corporation (does not operate mines)
4. Freeport-Mcmoran Inc.	4. Public Joint Stock Company Polyus
5. Golgohar Mining & Industrial P.J.S.C. (not enough data)	5. Teck Resources Limited
6. Southern Copper Corporation	6. Wheaton Precious Metals Corp. (does not operate mines)
	7. Newcrest Mining Limited

- Fig. 4. **Earth System Impact intensity compared to CO_2 intensity for mining assets** with revenues above $100M in our sample (n = 106). For each mine, the ESI score is also broken down to indicate the individual contribution of CO_2 emissions, landuse and water consumption to the total ESI score. Superimposed on the ESI intensity plot is the CO_2 intensity measure for each mine (black line), and mines are plotted (from left to right) according to their carbon intensity score.

CO2e alone does not give the needed systemic impact assessment on critical earth systems from mining