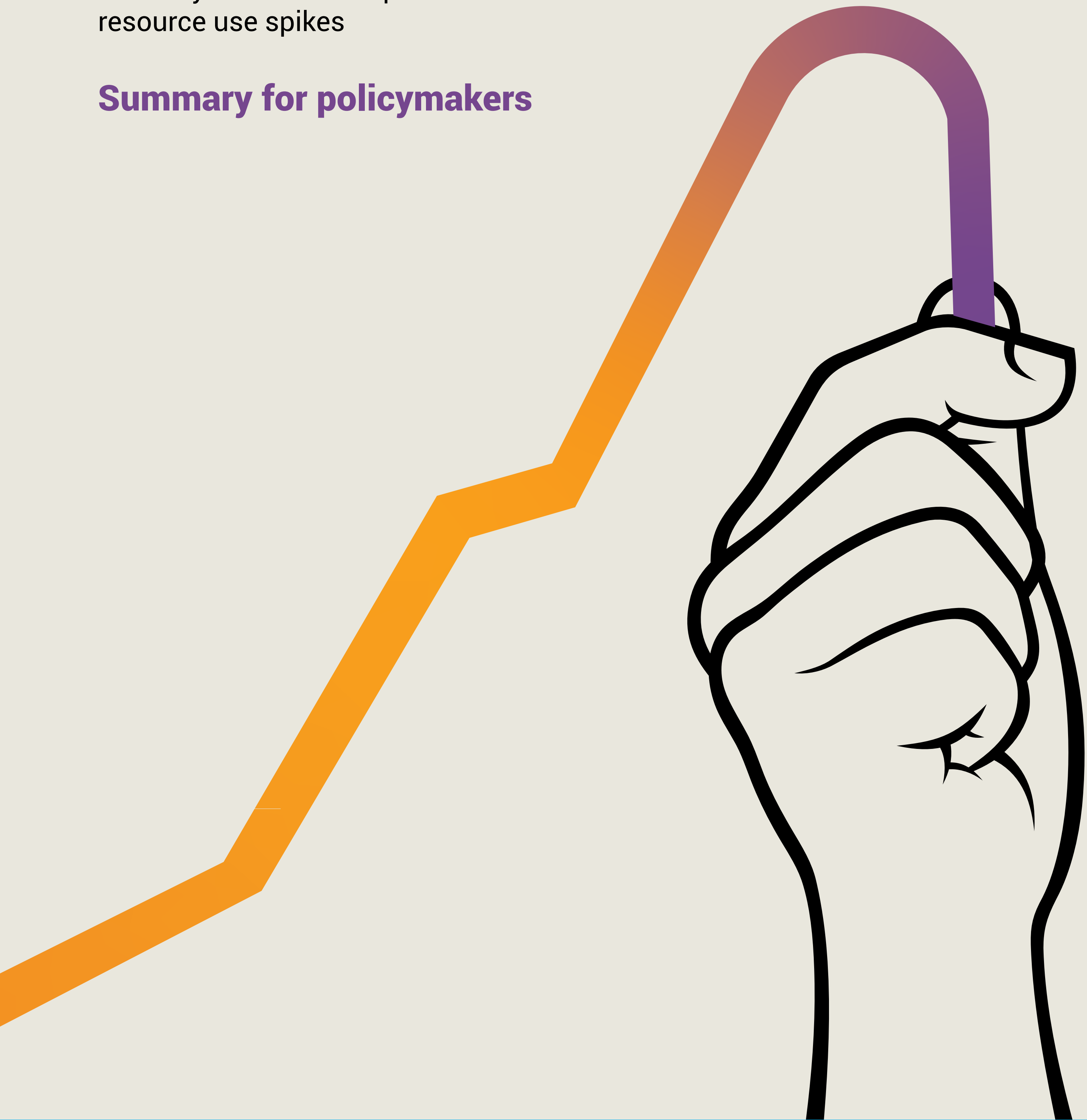
UN environment programme

Bend the trend

Pathways to a liveable planet as resource use spikes

Summary for policymakers



International Resource Panel

Global Resources Outlook
2024

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About the report series and the International Resource Panel

The first Global Resources Outlook (GRO) was launched in 2019 at the United Nations Environment Assembly (UNEP/EA.4/INF/18), and subsequently the International Resource Panel (IRP) was invited to report regularly to UNEA (Res. 4/1), including through its GRO reports, on current trends and emerging issues related to the use and management of natural resources, overconsumption and their impact on the environment, the economy, society and people.

This GRO 2024 report brings together the best available data, modelling and assessments to analyse trends, impacts and distributional effects of our resource use. While most of the datasets extend up to 2022, data for the years up to 2024 is modelled, leveraging the IRP integrated modelling framework wherever feasible. The calculations span over 180 countries and are further aggregated into seven world regions and four income groups. It also describes the potential to turn negative trends around and put humanity on a trajectory towards sustainability.

The International Resource Panel

The IRP was established to provide independent, coherent and authoritative scientific assessments on the use of natural resources and their environmental impacts over the full life cycle. The Panel aims to contribute to a better understanding of how to decouple economic growth from environmental degradation while enhancing well-being. Benefiting from the broad support of governments and scientific communities, the Panel is constituted of eminent scientists and experts from all parts of the world, bringing their multidisciplinary expertise to address resource management issues.

The information contained in the IRP's reports is intended to:

- be evidence based and policy relevant,
- inform policy framing and development, and
- support evaluation and monitoring of policy effectiveness.

Since the IRP's launch in 2007, more than 33 assessments have been published, which outline the numerous opportunities for governments, businesses and wider society to work together to create and implement policies that ultimately lead to sustainable resource management, including through better planning, technological innovation and strategic incentives and investments.

Credit: ©CIAT/NeilPalmer

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Foreword

Natural resources are the basis on which all economies and societies are built, making their sustainable management critical to ending poverty and reducing inequalities.

They are also essential to drive the transition to net-zero. To stay below a 2°C temperature rise by 2050, we will need over three billion tonnes of energy transition minerals and metals for wind power, solar and more. Aiming for 1.5°C to maximize climate justice would mean even greater demand.

Right now, however, resources are extracted, processed, consumed and thrown away in a way that drives the triple planetary crisis – the crisis of climate change, the crisis of nature and biodiversity loss, and the crisis of pollution and waste. We must start using natural resources sustainably and responsibly.

The 2024 edition of the Global Resources Outlook, from the International Resource Panel, shows that it is both possible and profitable to decouple economic growth from environmental impacts and resource use. In fact, sustainable resource use and consumption can reduce resource use and environmental impacts in wealthier countries, while creating the space for resource use to grow where it is most needed. It is important to note that the circular models we must follow are not just about recycling; they are about keeping materials in use for as long as possible, and rethinking how we design and deliver goods as well as services, thereby creating new business models.

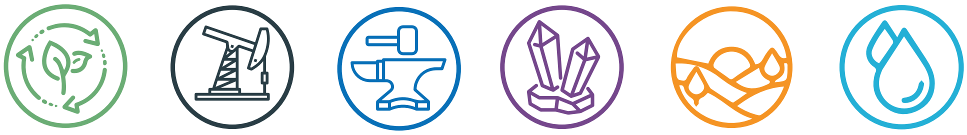
If the policies and shifts outlined in this report are followed, the 2060 picture will be significantly rosier than under current models. We could have a global GDP three per cent larger than predicted and reduced economic equalities. Growth in material use could fall by 30 per cent. Greenhouse gas emissions could be reduced by more than 80 per cent. Such results would be a huge win for people and planet.

The bottom line is that sustainable and responsible resource use and consumption is a key enabling factor for the success of virtually every international agreement and initiative aimed at carving out a better future – from the new Global Framework on Chemicals and upcoming legally binding instrument on plastic pollution to the Paris Agreement and the Sustainable Development Goals.

The scientific community is united about the urgent need for decisive policies to enable a sustainable future. We need bold and immediate actions at scale to rebalance humanity's relationship with the natural world and the resources it provides. I call on all policymakers to read this report and act on its findings as part of a united global push to make this world a better, more sustainable home for everyone.

Inger Andersen
Executive Director
United Nations Environment Programme

Preface



The messages from this report could not be clearer: It is no longer whether a transformation towards global sustainable resource consumption and production is necessary, but how to urgently make it happen.

The scale of impacts linked to the way material resources are extracted and processed for our global economy are astounding — over 55 per cent of greenhouse gas emissions driving us to the brink of climate catastrophe, up to 40 per cent of particulate matter health related impacts costing over 200 million disability-adjusted life years every year, and over 90 per cent of total land-use related biodiversity loss that is the lynchpin of vibrant ecosystems and life on Earth. If not addressed, the impacts of our resource use will derail all hope of meeting Multilateral Environmental Agreements like the United Nations Framework Convention on Climate Change, the United Nations Convention to Combat Desertification and the Convention on Biological Diversity.

Despite this, our insatiable use of resources has tripled over the last fifty years. As nations continue their urbanisation and industrialization, and the global middle class expands, there is a corresponding uptick in material use, waste, emissions, as well as water and land consumption. If we do not change, we could see resource use up by 60 per cent from 2020 levels by 2060. Our current deeply unsustainable systems of consumption and production will cumulate in catastrophic impacts on the earth systems and ecological processes that underpin human well-being and the diversity of life on our planet.

This can, and must, change. We should not accept that meeting human needs has to be resource intensive and we must stop stimulating extraction based economic success. This report demonstrates that compared to current trends, it is still possible to reduce resource use while growing the economy, reducing inequality, improving well-being and dramatically reducing environmental impacts.

Based on the outcomes of state-of-the-art scenario modelling, we outline five critical actions at all levels of governance that are essential to enable transitions to resource-efficient and sustainable consumption and production. These changes across the most resource-intensive systems that deliver shelter, nutrition, mobility and energy can improve well-being for all within planetary boundaries. Designing solutions for 'provisioning systems' incentivizes cross-sector innovation. This systems approach is a foundation of building the future-fit socio-economic models that use less resources and multiply the co-benefits for people and planet.

A monumental push towards sustainable resource management and enhancements in resource productivity is imperative. This must go hand-in-hand with responsible consumption, facilitated by strategic infrastructure investments, to guide the global economy towards sustainable and equitable utilization.

These findings are strongly aligned with the conclusions of other recognized science-policy panels. Scientists bring the best knowledge and illustrate potential pathways forward in increasingly bold manner. For UNEA-6, we hope that these findings will inform countries and spur action based on systemic plans and pledges with a central focus on resource use. With decisive action, political courage and bold boardroom decisions, a sustainable future – meaning a decent life for all within planetary boundaries – is possible.

Janez Potočnik and Izabella Teixeira
IRP Co-Chairs

Key messages: Headlines

A projected 60 per cent growth in resource use by 2060 could derail efforts to achieve not only global climate, biodiversity, and pollution targets but also economic prosperity and human well-being.

01 **Increasing resource use is the main driver of the triple planetary crisis.**

02 **Material use has increased more than three times over the last 50 years. It continues to grow by an average of more than 2.3 per cent per year.**

03 **Climate and biodiversity impacts from material extraction and processing greatly exceed targets based on staying within 1.5 degrees of climate change and avoiding biodiversity loss.**

Reducing the resource intensity of food, mobility, housing and energy systems is the best and only way of achieving the SDGs, the climate goals, and ultimately a just and livable planet for all.

04 **Delivering on the SDGs for all requires decoupling, so that the environmental impacts of resource use fall while the well-being contributions from resource use increase.**

05 **High-income countries use six times more materials per capita and are responsible for ten times more climate impacts per capita than low-income countries.**

06 **Compared to historical trends, it is possible to reduce resource use while growing the economy, reducing inequality, improving well-being and dramatically reducing environmental impacts.**

Reorienting demand and allowing resource use to grow where it is most needed will open pathways to achieving the SDGs and a shared and equitable prosperity for all.

07 **Bold policy action is critical to phase out unsustainable activities, speed up responsible and innovative ways of meeting human needs and promote social acceptance of the necessary transitions.**

08 **The prevailing approach of focusing on supply-side (production) measures must be supplemented with a much stronger focus on demand-side (consumption) measures.**

09 **The scientific community is united around the urgency of resolute action and bold evidence-based decisions that protect the interests and well-being of all, including future generations.**

Key messages

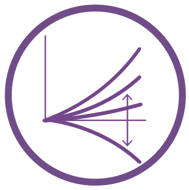
1. Increasing resource use is the main driver of the triple planetary crisis.

Extraction and processing of material resources (fossil fuels, minerals, non-metallic minerals and biomass) account for over 55 per cent of greenhouse gas emissions (GHG) and 40 per cent of particulate matter health related impacts. If land use change is considered, climate impacts grow to more than 60 per cent, with biomass contributing the most (28 per cent) followed by fossil fuels (18 per cent) and then non-metallic minerals and metals (together 17 per cent). Biomass (agricultural crops and forestry) also account for over 90 per cent of the total land use related biodiversity loss and water stress. All environmental impacts are on the rise.

2. Material use has increased more than three times over the last 50 years. It continues to grow by an average of more than 2.3 per cent per year.

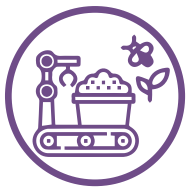
Material use and its impact continue to rise at a greater rate than increases in well-being (as measured by inequality-adjusted Human Development Index). The built environment and mobility systems are the leading drivers of rising demand, followed by food and energy systems. Combined, these systems account for about 90 per cent of global material demand. Material use is expected to increase to meet essential human needs for all in line with the Sustainable Development Goals (SDGs). Without urgent and concerted action to change the way resources are used, material resource extraction could increase by almost 60 per cent from 2020 levels by 2060, from 100 to 160 billion tonnes, far exceeding what is required to meet essential human needs for all in line with the SDGs.

3. Climate and biodiversity impacts from material extraction and processing greatly exceed targets based on staying within 1.5 degrees of climate change and avoiding biodiversity loss.



Analysis of scientific targets developed on the basis of Multilateral Environmental Agreements (MEAs) (such as the United Nations Framework Convention on Climate Change [UNFCCC], Convention on Biological Diversity [CBD] and United Nations Convention to Combat Desertification [UNCCD]) and scientific literature demonstrates the extent to which environmental impacts from resource use could derail their achievements. Integrating sustainable resource use in the implementation of MEAs is necessary to meet agreed climate, biodiversity, pollution and land degradation neutrality outcomes. Action is required now to lower GHG emissions, paying attention to the crucial role of materials. A sustainable and circular bioeconomy must be based on prioritizing the use of biomass to maximize well-being and minimize impact, while conversion of biodiversity-and carbon-rich natural systems must be avoided and reversed to promote net nature-positive outcomes.

4. Delivering on the SDGs for all requires decoupling, so that the environmental impacts of resource use fall while the well-being contributions from resource use increase.



Resource efficiency and supporting policies can reduce material resource use and dramatically reduce environmental impacts in high and upper middle-income countries (absolute decoupling) while improving well-being and boosting economic growth. This can also create the space for resource use to grow where it is most needed. There has so far been no evidence of widespread absolute decoupling at the global level. In low and lower middle-income countries policy should focus on reducing environmental pressures and impacts and improving resource efficiency, acknowledging increases in resource use (relative decoupling) will be required to reduce inequalities and improve well-being. These actions are aligned with the emerging understanding of just transitions, sufficiency and pathways towards sustainable resource use.

5. High-income countries use six times more materials per capita and are responsible for ten times more climate impacts per capita than low-income countries.

This inequality must be addressed as a core element of any global sustainability effort. The per capita material footprint of high-income countries, the highest of all income groups, has remained relatively constant since 2000. Upper middle-income countries have more than doubled their material footprint per capita approaching high-income levels, while their per capita impacts continue to be lower than high-income countries. Through global trade, high-income countries displace environmental impacts to all other income country groups. Per capita resource use and related environmental impacts in low-income countries has remained comparatively low and almost unchanged since 1995.

6. Compared to historical trends, it is possible to reduce resource use while growing the economy, reducing inequality, improving well-being and dramatically reducing environmental impacts.

Scenario modelling illustrates the potential to reduce and rebalance global per capita material use, with absolute reductions from around 2040 driven by reductions in high and upper middle-income nations that outweigh, in aggregate, increases in low and lower middle-income nations. The policies and shifts that could drive these change also reduce economic inequalities and boost global income growth. Integrated action on resource efficiency, climate and energy, food and land achieve significantly larger positive effects than any one of these policy areas for action would in isolation. Taken together, these actions demonstrate that by 2060, it is possible to achieve a world with global GDP about 3 per cent larger alongside a global Human Development Index 7 per cent higher than could be expected by following historical trends. Compared to historical trends such measures could mitigate growth in material use by 30 per cent. GHG emissions could be reduced by more than 80 per cent from current levels by 2060, consistent with the Paris Agreement, along with absolute reductions in energy use, agricultural land area, and other pressures. Fully embracing this scenario is the obvious choice.

7. Bold policy action is critical to phase out unsustainable activities, speed up responsible and innovative ways of meeting human needs and promote social acceptance of the necessary transitions.

The pathway towards sustainability is increasingly steep and narrow because much time has been lost and many policy commitments embedded in MEAs not delivered on. Urgent action is needed to institutionalise resource governance including embedding resources in the delivery of MEAs, defining sustainable resource use paths on all governance levels and, for example, developing multi-scale institutional arrangements in support of sustainable natural resource management. Equally important is reflecting the true costs of resources in the structure of the economy and the redirecting of finance towards sustainable resource use including through setting economic incentives correctly (including for example incentives addressing the rebound effect and subsidies reform), making trade and trade agreements engines of sustainable resource use, mainstreaming sustainable consumption options and creating circular, resource-efficient and low-impact solutions and business models.

8. The prevailing approach of focusing on supply-side (production) measures must be supplemented with a much stronger focus on demand-side (consumption) measures.

We reject the assumption that meeting essential human needs should be resource-intensive. Structurally lowering or avoiding resource-intensive demand in high consumption contexts is necessary. By addressing the demand-side, we are also addressing questions of global equity and sufficiency. For example, dietary changes reducing high-impact commodities including animal protein and food loss and waste can decrease the land needed for food by five per cent by 2060 compared to 2020 levels while more equitably ensuring adequate nutrition for all. Reducing the need for mobility and enabling mobility through shared and active transport can reduce related material stock requirements (-50 per cent), energy demands (-50 per cent) and GHG emissions (-60 per cent) by 2060 compared to current trends. Compact and balanced neighbourhoods using more recycled building content, lifespan extension and other circular economy measures can decrease building material stocks by 25 per cent by 2060, which leads to a 30 per cent decrease in energy demand and 30 per cent decrease in GHG emissions compared to current trends.

9. The scientific community is united around the urgency of resolute action and bold evidence-based decisions that protect the interests and well-being of all, including future generations.

The alignment in messages coming from the International Resource Panel, the Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services must be considered as a strong statement of urgency from the scientific community. The only choice is to stabilize and balance the human relationship with the rest of nature. Weak, partial, fragmented or slow policies will not work. This can only be possible with far-reaching and truly systemic shifts in energy, food, mobility and the built environment implemented at an unprecedented scale and speed. Leaders across all sectors, including government at all levels, business and civil society must act now. We can make these changes, and improve human well-being around the world, but the window of opportunity is closing.

Summary for Policymakers

Better resource management is essential for the 2030 Agenda for Sustainable Development to succeed

Credit: @UNEP

People depend on natural resources for all basic needs and as a basis for well-being. How these resources are extracted, processed, traded, transformed, used and eventually disposed not only determines the trajectories of environmental impacts, but also underpins all 17 Sustainable Development Goals (SDGs). Figure 1 depicts how provisioning systems—like food and nutrition (here referred to as 'food'), energy, mobility and the built environment[1]—rely on the extraction of resources to deliver human well-being and the SDGs, while at the same time also creating impacts on the environment and consequently, people.[2]

The provisioning systems perspective makes clear that the resource agenda is not only relevant to the environmental agenda. It refers to the long-term capacity of natural systems to deliver secure well-being to all, which is essential for humanity to thrive in peace. An environmentally sustainable economy with decent work and social justice is essential to the well-being of current and future generations. This is acknowledged in the context of climate change mitigation and adaptation under the UNFCCC (see International Labour Organization [ILO] 2022), where just transitions have become "increasingly fundamental to the transition to a low-carbon economy" (Katowice Committee on Impacts [KCI] 2022).

The science is clear. The key question is no longer whether a transformation towards global sustainable resource consumption and production is necessary, but how to make it happen now.

1 The GRO 2024 primarily analyses these four resource-intensive provisioning systems. Other systems could include, for example, communication, waste management, resource recovery, education, clothing and hygiene and sanitation among others. These are not treated exhaustively by the GRO 2024.

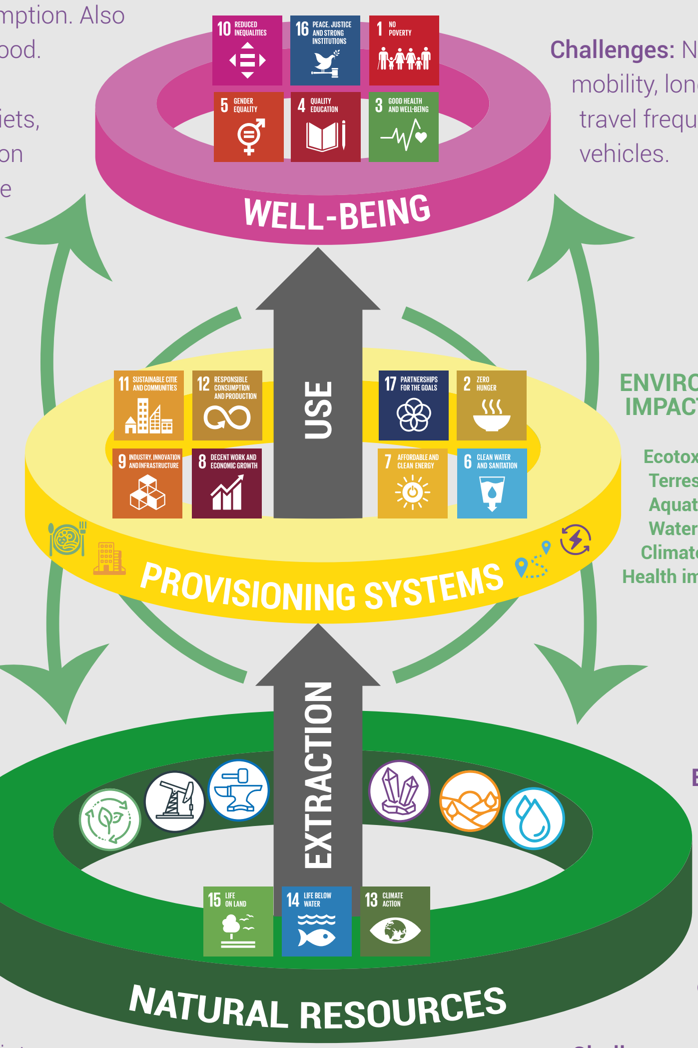
2 Provisioning systems account for the use of resources and related impacts from all sectors that contribute to meet the final demand of products and services of each system. This means, for example, that energy used to produce food, for building or for mobility will be assigned to each of these respective systems. This differs from the sectoral classifications used under, for example, climate mitigation reporting, where the energy sector includes most activities producing energy, and are not assigned to final consumption sectors.

FOOD AND NUTRITION: Resource use and corresponding supply chains that contribute to human nutrition, including each step in the food supply chain, from production to distribution, retail and consumption. Also the energy used to produce food.

Challenges: Unsustainable diets, food loss and waste, impact on ecosystems, carbon-intensive supply chains and competition with other potential applications of biomass.

MOBILITY: Land, sea and air mobility, and associated infrastructure for transporting people and goods, and the energy for their manufacture and running, including vehicle fuel.

Challenges: New lock-ins in motorized mobility, long-distance travel and high travel frequency and carbon-intensive vehicles.



ENVIRONMENTAL IMPACTS:

Ecotoxicity
Terrestrial biodiversity loss
Aquatic biodiversity loss
Water stress
Climate change
Health impacts

BUILT ENVIRONMENT: Constructed spaces for human activity, where people live and work, and the energy embodied in their construction. Built infrastructure used by other systems would not fall into this system.

Challenges: Lock-ins in buildings with high energy demand, high floor area and energy demand per capita, high emissions embodied in construction and competition with other uses of biomass.

ENERGY: Production, conversion and supply of energy for end-consumer and its associated infrastructure. Most energy use is allocated to other provisioning systems.[3]

Challenges: Carbon lock-ins in industries and infrastructure, high energy demand from other provisioning systems, limited supply of decarbonized electricity supply and low-carbon fuels, high demand of materials for the low-carbon transition and competition for the use of biomass.

Biomass · Fossil fuels · Metals · Non-metallic minerals · Land · Water

Figure 1: From natural resources to provisioning systems and societal well-being

The figure illustrates how natural resources (biomass, fossil fuels, metals, non-metallic minerals, land and water) are extracted and used through provisioning systems (in this report, the primary focus is on food, the built environment, energy and mobility) to deliver human well-being, while also impacting the environment and therefore people. This process is linked to the Sustainable Development Goals. (Source of the figure: Adapted from UNEP [2021 – Figure ES.1] and O'Neil *et al.* [2018 – Figure 1]. Design concept by: Namita Sharma and Iris Lassus)

3 For example, rail infrastructure and roads form part of the mobility system.

Material use has increased more than three times over the last fifty years and it continues to grow on average over 2.3 per cent per year

Growing living standards have resulted in a rapidly increasing extraction[4] of material resources (biomass, fossil fuels, metals and non-metallic minerals). By 2024, we can expect global material extraction to have surged from 30 billion tonnes in 1970 to 106.6 billion tonnes. The global financial crisis of 2008 and the recent global COVID-19 pandemic slowed the growth in resource extraction temporarily, but growth rates have since recovered. While large disparities based on country income level exist, to satisfy global demand each person now uses on average 13.2 tonnes of materials per year. This is up from an average of just 8.4 tonnes per person fifty years ago.

While material extraction has grown, material productivity[5] has stagnated and grows more slowly than GHG emissions, energy and labour productivity (Figure 2(b)). Thus, even though ever more resources are extracted and used, the economic growth following from these materials doesn't increase at a similar rate, indicating a material productivity gap. This material productivity gap is more evident when looking at income groups. In 1970, high-income countries had nine times the material productivity of low-income countries. By 2024, the ratio is projected to be thirteen times. The average material productivity of lower and upper middle-income countries has remained around 20 per cent of the average in high-income countries.

The composition of material use has changed profoundly over the last five decades, reflecting the general trend of transformation of economies from agrarian to industrial

While such changes have meant that the share of **biomass** – including crops, crop residues, grazed biomass, timber and wild-caught fish – has gone from 41 per cent to just over 25 per cent between 1970 and 2020, biomass extraction has increased in absolute terms, almost doubling. Crop harvest and grazed biomass for livestock animals have grown sharply, the latter reflecting the increasing popularity of animal and dairy-based diets among an expanding middle class across the world.

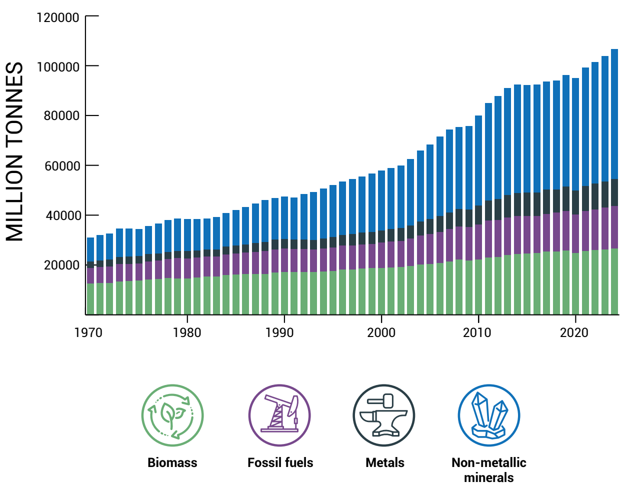


Figure 2(a): Global material extraction, four main material categories, 1970 – 2024, million tonnes
(Source: UNEP-IRP (2023) Global Material Flow and Resource Productivity Database)

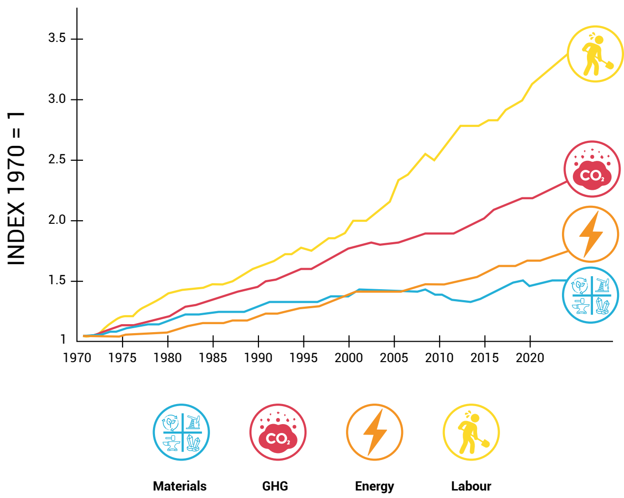


Figure 2(b): Global resource productivity of materials, GHG emissions, energy and labour productivity, 1970 – 2024, index
(Source: EDGAR World Emission Database; IEA World Energy Database; Penn World Table version 10.01; UNEP-IRP (2023) Global Material Flow and Resource Productivity Database)

4 Extraction is the amount of material extracted from the natural environment for use in the economy. It includes extractive activities such as mining as well as agricultural and wood harvest. Processing is conversion to refined materials, food and fuels.
5 Which measures the ratio of GDP to domestic material consumption.

Credit: ©Unsplash/ Dominik Vanyi

On the other hand, **non-metallic minerals** – including sand, gravel, clay and other minerals for industrial applications such as concrete – are the largest component of material use and posted a fivefold increase in extraction levels, from 9.6 billion tonnes to 45.3 billion tonnes. This level is close to 50 per cent of all total global materials extracted and is related to the massive build-up of infrastructure in many parts of the world.

The share of **metals** (metal ores) has grown slightly from 9 per cent to around 10 per cent in 2020. While it is the smallest share of all material categories, it has experienced a more than threefold increase since 1970 (from 2.6 billion to 9.6 billion tonnes) and contributes significantly to global climate impacts[6] (8 per cent) and particulate matter health related impacts (13 per cent) (data for year 2022). Fifteen per cent of the climate impacts of the built environment is attributed to metals. Urbanization is driving increases in iron ore extraction, while the key role of metals, especially those essential for energy transition technologies, is projected to lead to very high increases in material demand up to 2050.

Fossil fuels are the most traded primary materials contributing almost half of global trade of materials in 2020. While their share of global extraction has decreased from 20 per cent to 10 per cent and the use of coal has stagnated, there has been an increasing reliance on coal energy to process materials, especially metals, construction materials and chemicals. More than half of global coal use was used for the production of these materials (Cabernard *et al.* 2022). Extraction and processing of fossil fuels contribute 18 per cent of total climate impacts.

Global **water** withdrawal (freshwater removed from surface ground water) increased from around 3.5 trillion m^3 in 2000 to 4 trillion m^3 in 2020. On a per capita basis this represents a reduction from 566 m^3 per person in 2000, to 516 m^3 per person in 2020. In 2020, the share of water withdrawal of the agricultural and municipal sector increased from 67 to 72 per cent and from 11 to 13 per cent, respectively, while the share of the industrial sector decreased from 22 to 15 per cent. Water stress is largely driven by agriculture and has significantly increased since 2000.

Land under intensive use (land substantially modified which is used for agriculture, forestry and urban land) increased from 44.5 million km^2 in 1970 to 49.8 million km^2 in 2022. Between 1970 and 2022, pasture land accounted for five per cent less of land under intensive use (from 68 to 63 per cent), while crop cover increased by 1 per cent (to 31 per cent). Urban land use shares doubled from 1 to 2 per cent, while (intensive use) forestry quadrupled from 1 to 4 per cent. On a per capita basis, intensive land use per capita almost halved from 1.2 hectares (ha) in 1970 to 0.63 ha in 2022. Land use related biodiversity loss is concentrated in tropical regions and islands that harbor many endemic species leading to high biodiversity loss when natural habitats are lost.

6 GHG or Carbon Footprints as measured by tonnes of CO_2-equivalents (t CO_2-eq)

Material extraction, consumption and impacts differ across country income groups. This inequality must be addressed as a core element of any global sustainability effort

Trends in domestic extraction have shifted, with upper middle-income countries measuring the highest rate of domestic material extraction per capita

Most materials are extracted in upper middle-income countries, which have more than doubled their material extraction between 2000 and 2020. This means that upper middle-income countries extract twice the level of high-income countries and extract the same levels per capita (around 19 tonnes). Extraction in lower middle- and low-income countries remains around five tonnes per capita. These trends in extraction reflect two major dynamics. The first is the rising demand for materials to build up infrastructure. The second driver is the outsourcing of material and energy intensive stages of production by higher income countries to the upper middle-income group of transitioning economies. This relocation of resource intensive processes to middle-income countries has in several cases been driven by lower environment standards and lower labour costs.

High-income countries continue to use six times more materials per capita than low-income countries

The annual material footprint – the quantity of materials that are extracted and processed globally to meet the consumption of an individual country – of upper middle-income countries is the highest of all income groups it has more than doubled since 2000. It is followed by high-income countries, whose material footprint remained rather stable since 2000 with growth largely mitigated by technology.[7] On a per-capita basis, middle-income countries (lower and upper-middle income together) have more than doubled thier material footprint over the same period and are approaching high-income country per capita levels driven by growing populations and increasing affluence. However, the per capita environmental impacts of middle-income countries continue to be lower than high-income countries. Per capita material footprint in low-income countries has remained comparatively low and almost unchanged since 2000. The different level of impacts caused by this diverse use is covered later in this document.

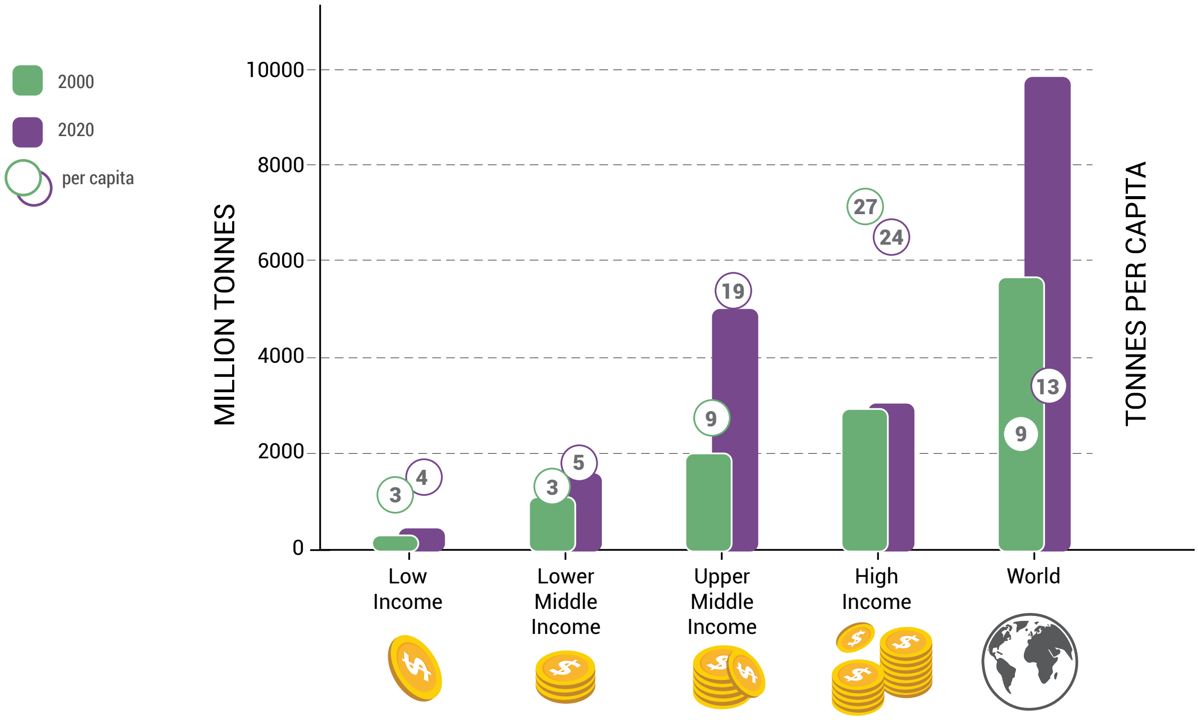


Figure 3: Material footprint by income groups
(Source: UNEP-IRP (2023) Global Material Flow and Resource Productivity Database)

7 Technology reflects all other drivers other than population and per capita income combined.

Built environment and mobility systems are the leading drivers of rising material demand, followed by food and energy systems

Combined, the resource-intensive provisioning systems of the built environment, mobility, food and energy, account for about 90 per cent of global material demand, 70 per cent of climate impacts and more than 80 per cent of biodiversity loss and water stress. Figure 4 points out the different contribution of provisioning systems to the share of material footprint by country income group. Food systems are the most important contributor to material footprint for low and lower middle-income countries, while the built environment and mobility are the most important contributor for upper middle-income and high-income groups.

Affluence is a major driver of the expected increases in global material use

Over the past twenty years, affluence explains 40 per cent of the global increase of material extraction, while population contributed to 27 per cent.Technology is found to only mitigate global material extraction by five per cent. As countries industrialised and well-being improved, affluence became the primary driver of increases in domestic extraction except in Africa, West Asia and Latin America and Caribbean countries. Population is the main driver of increased material use in Africa and West Asia. Material use is expected to increase, including meeting the SDGs for all and to build-up essential infrastructure. Without urgent and concerted action to change the way resources are used, resource extraction could increase almost 60 per cent by 2060 as compared to 2020 levels, with related devastating environmental and particulate matter health related impacts.

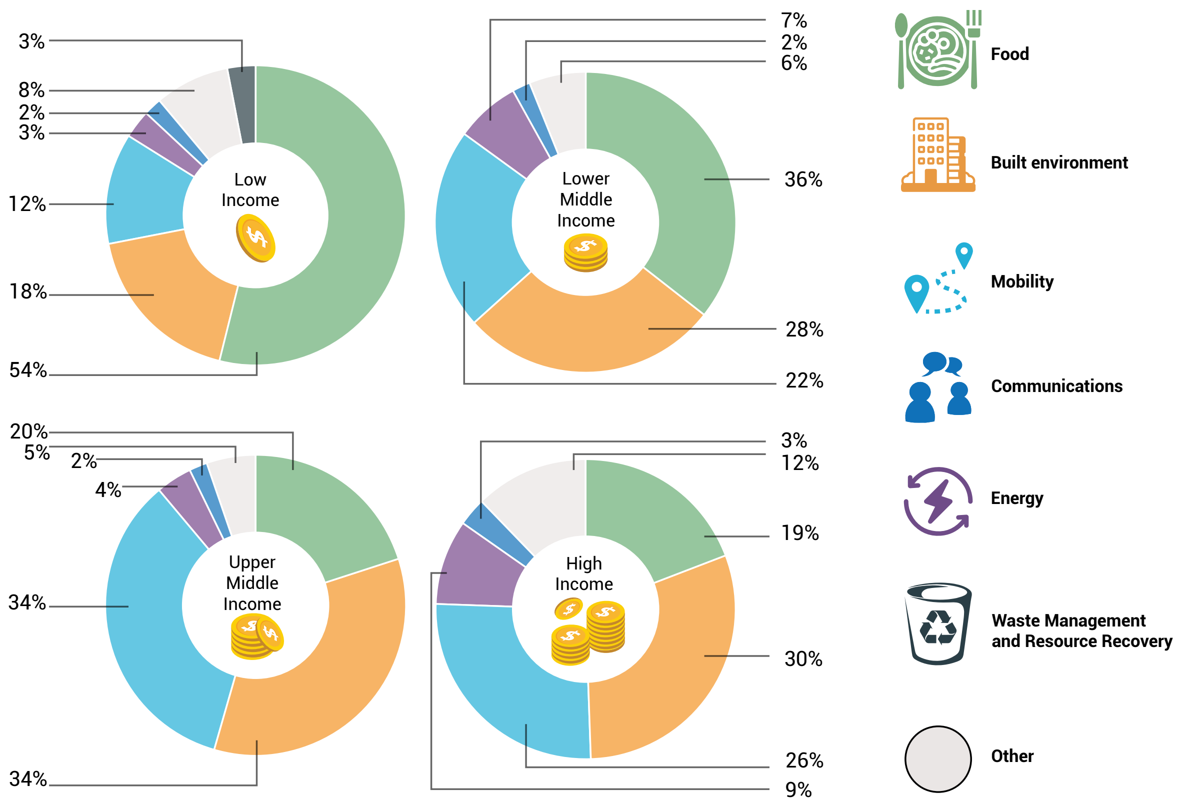


Figure 4: Shares of material footprint by provisioning systems and by country income group, 2020, percentage
(Source: UNEP-IRP (2023) Global Material Flow and Resource Productivity Database)

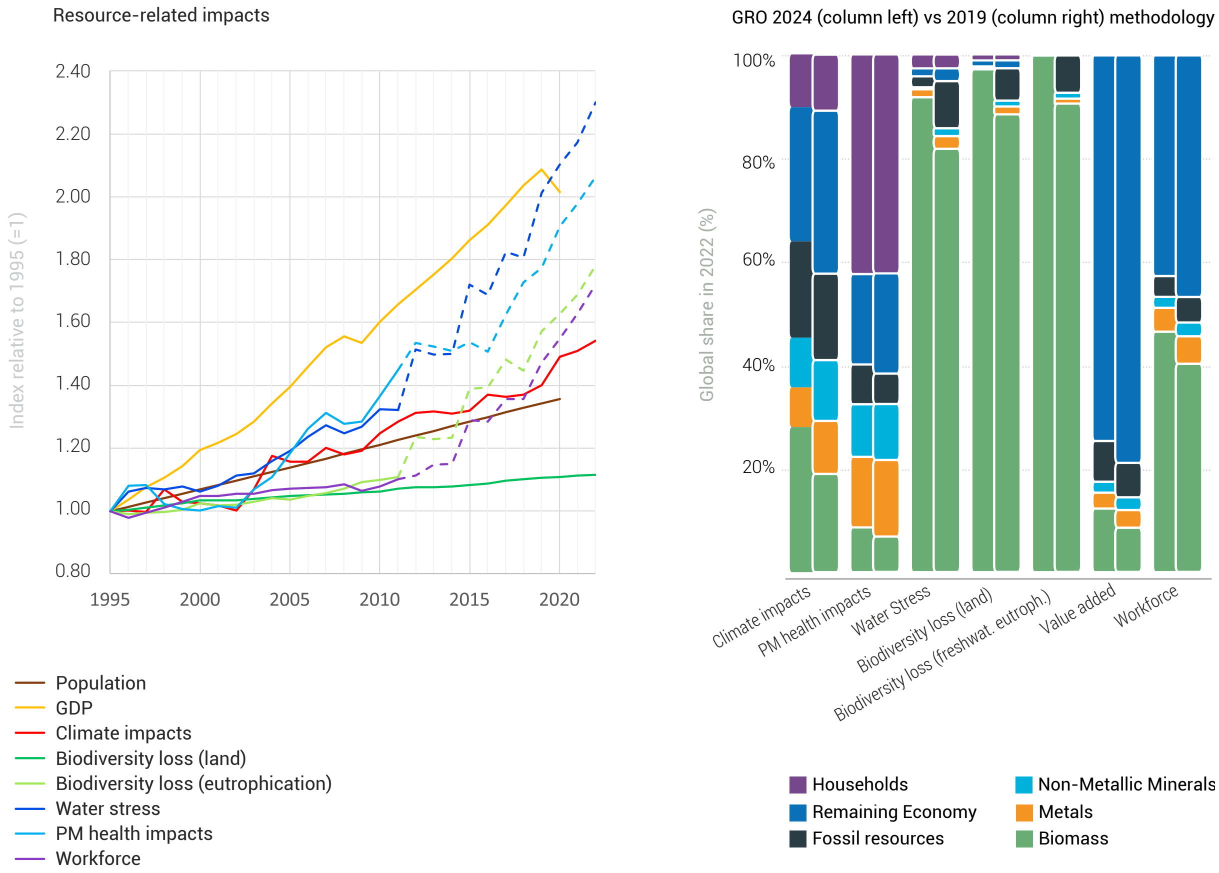


Figure 5: ***Left:*** **Temporal development (index, where 1995 values = 1) of resource-related environmental impacts and socio-economic indicators (from resource extraction and processing up to 'ready-to-be-used' materials, food or fuels) compared to drivers of population and GDP growth, 1995-2022.**
Notes: Dashed lines are partially based on nowcasted data after 2012 (Tukker 2016) and are therefore uncertain.
Figure 5: ***Right:*** **Relative contribution of different types of resources (extraction and processing), the remaining economy (downstream use of resources in the economy after extraction and processing) and households (impacts of direct emissions and resource consumption) to global environmental and socioeconomic impacts for 2022.**
Notes: Left columns refer to the updated methodology (considering land-use change climate impacts, in addition to land occupation and emissions, minor changes in the sector classification) and right columns to the previously used methodology to allow for comparability with GRO 2019.

Increasing resource use is the main driver of the triple planetary crises

Growing and harvesting biomass, extracting metallic and non-metallic minerals and fossil fuels, and processing of materials, fuels and food accounts for over 55 per cent of GHG emissions and up to 40 per cent of particulate matter health related impacts. If land use change is considered, climate impacts grow to more than 60 per cent.[8] Non-metallic minerals and metals together account for around 17 per cent GHG emissions and almost a quarter (24 per cent) of global pollution.

Growing and harvesting biomass (agricultural crops and forestry) contributes over 90 per cent of total land use related biodiversity loss and water stress. Between 2015 (last reference year of the previous edition of this report (International Resource Panel [IRP] 2019) and 2020 there was no absolute decoupling – the impacts from resource use declining while the economy grows – on the global scale (Figure 5). All environmental impacts increased in absolute terms, with only a few temporary dips. Despite these impacts, resource extraction and processing created only 25 per cent of global economic value added. While about 50 per cent of the global workforce is employed in resource extraction and processing, particularly in agriculture, and most of this employment are low-paid jobs.

8 Results in the 2019 edition of the Global Resources Outlook showing that material extraction and processing contribute to more than 50 per cent climate impacts were based on a methodology that did not account for the climate impacts of land use change. Using that same methodology, 55 per cent climate impacts can now be linked to the extraction and processing of material resources. The 2024 edition of the Global Resources Outlook improved the methodology and now accounts for these impacts, showing over 60 per cent of GHG emissions linked to extraction and processing of material resources.

Affluence is a major driver of the environmental impacts from resource use, and high-income countries are responsible for ten times more climate impacts per capita than low-income countries

The biggest increases in terms of impacts from consumption were in upper middle- income countries (Figure 6). However, on a per capita basis, high-income countries are responsible for around two times more climate impacts than upper middle-income countries and ten times more than low-income countries. Per capita environmental impacts in low-income countries have remained comparatively low and almost unchanged since 1995.

Substantial environmental impacts are embodied in global trade, where high-income countries displace environmental impacts to all other income country groups, i.e. they import resources and materials which cause environmental impacts in the exporting regions. For example, in 2022, more than half of global land use related biodiversity loss occurred in Africa and Latin America, but less than 10 per cent of global economic value added was generated in these regions. Vice versa, almost half of global value added was generated in Europe and North America, although less than 10 per cent of global water stress and biodiversity loss happened in these regions.

This opposing pattern of lower domestic environmental impacts and higher value added is partially a sign of higher environmental standards and regional conditions of water scarcity and biodiversity, but also a consequence of impact displacement from high-income to all other income country groups.

Almost half of the impacts in Latin America and Africa are connected to producing food and other biomass products for export, with an increasing trend in Latin America. Asia and the Pacific turned from an initial exporter of goods causing biodiversity loss to an importer (with increasing trend). Net value added attached to trade is less than one per cent of the global value added.

Over time, per capita climate footprints have decreased in North America and Europe but increased in all the other regions. Nevertheless, per capita climate footprints are still distinctly higher in North America compared to all the other regions. A similar pattern is observed for water stress footprints, which increased most strongly in Asia and the Pacific and Africa, but which are still highest in North America and Europe, as well as West Asia. Land-related biodiversity loss footprints are two times higher in Latin America and the Caribbean compared to all the other regions, due to their unique ecosystems.

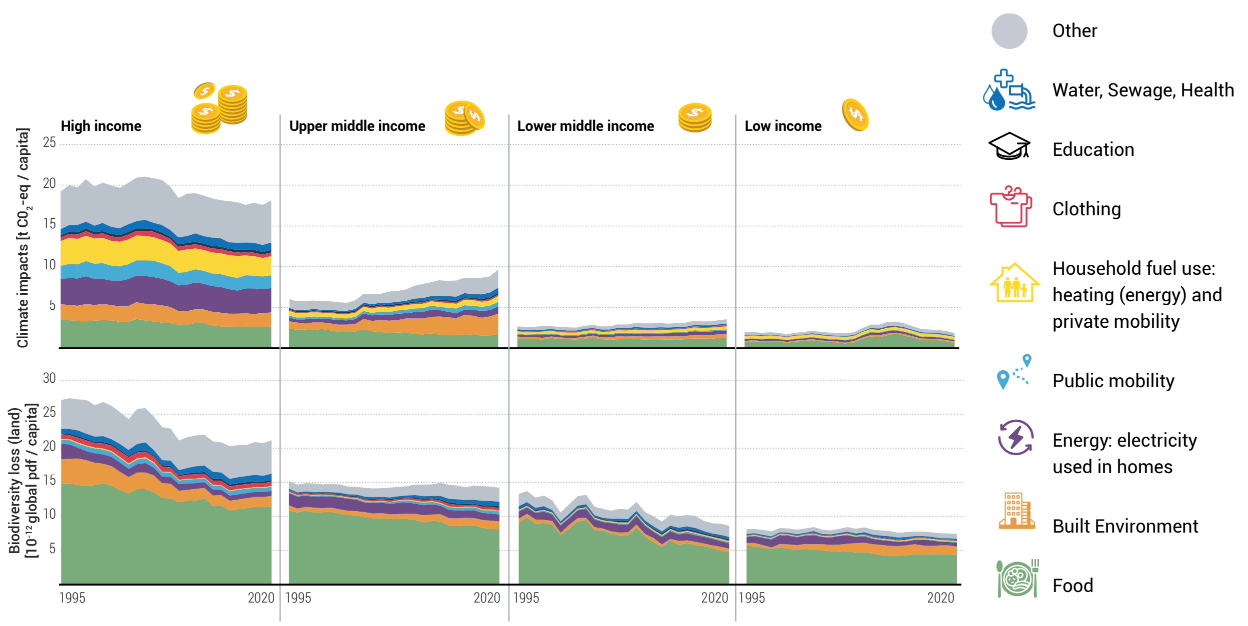


Figure 6: Environmental footprints (consumption perspective) on a per capita basis allocated to provisioning systems from 1995 to 2020 by income group

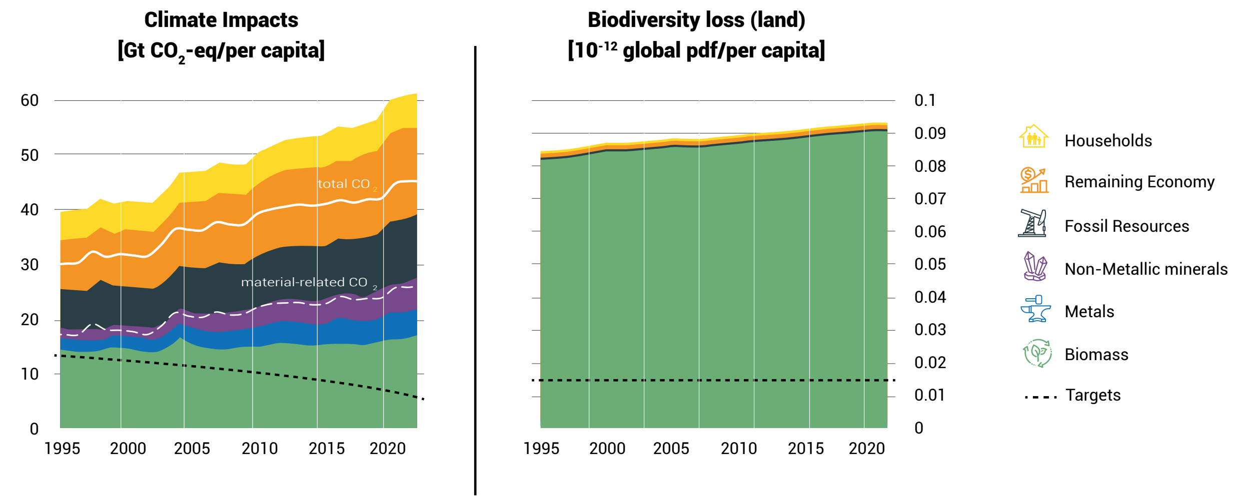


Figure 7: Time series of climate change impacts (left) and land occupation biodiversity loss (right) split by material resource group (including cultivation/extraction and processing) and downstream use (remaining economy and households).
Notes: The black striped lines show indicative targets. For climate change, this curve is declining, as the target is a CO_2-budget, which decreases every year due to overshoot of annual targets. For biodiversity loss, pdf stands for "potentially disappeared fraction of global species". In addition to GHG (coloured areas), also the total (purple curve) and the total material-resource related CO_2 emissions (white curve) are shown to enable a comparison with the target (which does not comprise GHG other than CO_2).

Greenhouse gas emissions and biodiversity impacts from material extraction and processing greatly exceed targets based on staying within 1.5 degrees of climate change and avoiding biodiversity loss

Possible and indicative targets derived from intergovernmental agreements (such as the UNFCCC, CBD and UNCCD) and scientific publications to benchmark the state of climate and biodiversity impacts demonstrate the extent of environmental impacts from resource use. The GRO assessment illustrates how this can derail commitments to global climate and biodiversity agreements (the Paris Agreement and Kunming-Montreal Global Biodiversity Framework aiming to halt global species loss). For example, in 2022, the extraction of resources and processing to food, materials and fuels emitted multiple times more CO_2 than the posited target would allow for all human activities together (Figure 7, left). Also, a target of species loss related to land use (land occupation) was exceeded six times (Figure 7, right). This shows that even if we stop converting land (land use change), we still have to reduce impacts from current land use to be in line with suggested targets and meet biodiversity goals.

Climate impacts are caused by a wide variety of actors in multiple sectors across provisioning systems

The growing and harvesting of biomass has the largest contribution to the total GHG emissions of all material categories (28 per cent), followed by fossil fuels (18 per cent) and non-metallic minerals and metals together contribute 17 per cent. Decarbonization of material production and the supply chain of materials, and increased material efficiency are urgently needed to mitigate climate change and pollution-related health impacts. These strategies should move into the centre of attention of climate policy.

Provisioning systems contribute differently to climate impacts. Energy and mobility represent together 29 per cent, food 23 per cent and the built environment 17 per cent of the total impacts. Half of the climate footprint of the built environment is attributed to cement, bricks and elements made of concrete. The remaining fraction is attributed to metals (15 per cent), fossil resources (29 per cent) and biomass, mostly wood and rubber (10 per cent). The majority of harvested and extracted materials are used just once, underscoring the underutilized potential for increased circularity and loop-closure in socio-economic systems.


Credit: ©Axel Fassio/CIFOR-ICRAF

Growing and harvesting biomass resources (agriculture and forestry) are the most important contributors to biodiversity impacts and water stress

Almost 75 per cent of land-related biodiversity impacts come from agriculture, while forestry accounts for 23 per cent. Animal-derived food products cause more biodiversity impacts than the entire remaining food production. This calls, for example, for reducing animal-derived food and food waste.

Relatively few industrial sectors – mainly food related sectors (agriculture, retailers and food services), wood related industries (forestry and construction) and increasingly biochemicals – are responsible for the major share of biodiversity loss. Biodiversity impacts mainly occur at the start of the value chain. Policies should focus on these intervention points in constructing a more circular and sustainable bioeconomy.

A transition to a sustainable and circular bioeconomy is critical and must be based on prioritising the use of biomass for maximum well-being and minimal impact. Conversion of biodiversity- and carbon-rich natural systems must be avoided and reversed, to promote net nature-positive outcomes and contribute to a less polluted environment. Since the availability of sustainable biomass is limited, its use should be in accordance with the cascading principle of biomass use, and for long-term applications with biogenic carbon storage effects replacing materials with larger impacts.

Mining is globally less relevant for global land use related biodiversity impacts than other activities (<1 per cent of total global biodiversity impacts) but can be locally important. The scale of current mining conflicts[9] is also seen as a further risk, which relates to the negative and social impacts of extractive activities.

Every year more than 200 million life years are lost (disability-adjusted life years) due to $PM_{2.5}$

Primary and secondary emissions of fine particulate matter ($PM_{2.5}$) are the predominant source of health impacts from environmental pollution. Every year more than 120 million life years are lost (disability-adjusted life years - DALYs) due to outdoor $PM_{2.5}$ and 80 million DALYs due to indoor pollution (Lozano *et al.* 2020). Household mobility and heating demand are estimated to contribute up to 40 per cent of the outdoor $PM_{2.5}$ health burdens, while the industrial activities supplying fossil energy, and processing metals and non-metallic minerals are responsible for more than 30 per cent. The remainder is largely due to agriculture. The downstream impacts would be even larger if indoor particulate matter exposure effects were analysed.

9 The Global Environmental Justice Atlas (15 April 2023) identifies extraction of mineral ores and building materials (both categories appear aggregated) as one of the largest categories of environmental conflicts, among 3,861 conflicts. The concentration of mining conflicts in the Andes in South America is particularly high.

Some human needs have been met without significant environmental impacts

Between 2010 and 2022, inequality-adjusted Human Development Index (IHDI) values increased for all country groups but so too did the environmental impacts. However, the observed correlations between human development on one hand and climate change and biodiversity loss impacts on the other hand need not be a given for the future. Many countries, especially in Africa, managed to increase inequality-adjusted life expectancy without increasing per capita climate impacts. However, most African countries remained on a rather low level of inequality-adjusted life expectancy and education despite this increase (generally below 60 years and 8 years, respectively). In Latin America, Chile, Argentina, Costa Rica and Ecuador achieved a high inequality-adjusted life expectancy (more than 70 years) and education (more than 10 years) while keeping climate impacts comparably low. However, in Europe, North America and Asia and the Pacific, a high inequality-adjusted life expectancy above 70 years was associated with almost exponentially increasing climate impacts.

Failure to implement radical changes will result in increasing environmental damage and inequality

Without any change, our current deeply unsustainable systems of consumption and production will gradually grow and culminate in catastrophic impacts on the Earth systems and ecological processes that underpin human well-being and the diversity of life on our planet.

Two scenario models are explored in the GRO24. The first, a *Historical Trends* scenario where the world continues onwards according to current trajectories and policies sees all key pressure and impact indicators increase in absolute terms, driving increasing damage and risks. Global resource use grows strongly to 2050 before stabilising. Key pressure indicators include resource extraction up around 60 per cent from 2020 levels to 2060 (from 100 billion to 160 billion tonnes), primary energy up 50 per cent, food and fibre biomass extraction up 80 per cent and the area of agricultural land up 5 per cent, displacing native habitat and increasing biodiversity risks. Key impact indicators include net GHG emissions up more than 20 per cent compared to 2020 levels and increasing biodiversity losses.

The resource use curve can be bent while growing the economy, reducing inequality, improving lives and dramatically reducing environmental impacts

The world does not have to choose between either economic growth and development or stronger environmental protection. Well designed and implemented polices can deliver both at the same time, lifting sustainable economic growth and well-being while also moderating pressures and reducing environmental impacts. This is the concept of decoupling. Resource use is necessary to deliver on the SDGs for all, but pressures and impacts of resource use on the environment must be reduced. At the same time, resource efficiency can provide for human needs and improve the well-being outcomes achieved from resource use.

Decoupling is not a one-size-fits-all approach

Delivering on the SDGs for all requires decoupling, so that environmental pressures and impacts of resource use fall, while the well-being contributions increase. In practice, this has different implications for groups with different levels of resource use and resource footprints.

For population groups (e.g. countries and fractions of the population within countries) with the highest resource consumption footprints policies and actions must lead to *absolute decoupling*, i.e. reduction of resource use from current levels. The scenario modelling finds policies can reduce per capita resource use while boosting income and well-being. Consistent with this, the Intergovernmental Panel on Climate change (IPCC) (2022) reports that consumption (demand-side) measures including diets with less animal protein, compact cities and more public transport can reduce GHG emissions by between 40 and 70 per cent by 2050. For the least developed contexts, where resource use is expected to grow to enable dignified living[10], the aim should be to improve resource efficiency and limit the growth of resource use (*relative decoupling*).

For all contexts, *impact decoupling* is a necessary condition for any resource use trajectory to be considered sustainable, reducing environmental and health impacts from current levels, and ensuring outcomes consistent with those agreed in MEAs. These differential decoupling paths for resource use and associated pressures and impacts are aligned with the emerging understanding about just transitions, sufficiency and pathways towards sustainable resource use.

10 This concept goes back to the United Nations Conference on the Human Environment in 1972 in Stockholm, which takes human dignity as a central concept and links it explicitly to the use of natural resources and the state of the environment.

Targeted and coordinated sustainability actions can limit resource use and reduce related environmental impacts, while delivering socio-economic development for all

The *Sustainability Transition* scenario, modelled by the IRP, demonstrates that a group of policy packages and societal shifts (Figure 8) implemented together can moderate resource pressures while also achieving stronger economic growth and human development outcomes globally.

The *Sustainability transition* scenario demonstrates IRP's decoupling concept in practice, and for the first time, puts numbers to the IRP's decoupling graph (see Figure 9). According to this scenario, global resource extractions peak in 2045 and then stabilise (falling slightly) to be around 20 per cent above 2020 levels in 2060, while the global economy grows 3 per cent more as compared with following historical trends. The mix of resource use shifts towards renewables, with food and fibre biomass extraction increasing by 40 per cent to 2060. Primary energy use falls by around 25 per cent by 2040 and then stabilises. The area of agricultural land falls around five per cent while agricultural output increases. The combined effect of the measures that make up this scenario reduce global material consumption by around 30 per cent relative to *Historical Trends* for 2060.

The *Sustainability Transition* scenario also finds key impact indicators fall from current levels for climate, while biodiversity impacts moderate. GHG emissions fall more than 80 per cent by 2060. Legacy effects of past actions drive ongoing biodiversity losses; however sustainability measures see these being 38 per cent lower than projected for *Historical Trends*.

These reductions in pressures and impacts are achieved while well-being and economic performance improve, with HDI up 7 per cent globally by 2060 and GDP per capita up 109 per cent in the *Sustainability Transition* scenario, both higher than projected for *Historical Trends* scenario. The modelling also demonstrates that achieving these reductions in pressures and impacts can also make it easier for developing countries to achieve their socio-economic and environmental objectives under the 2030 Sustainable Development Agenda enabled by stronger economic growth and reduced economic inequalities.

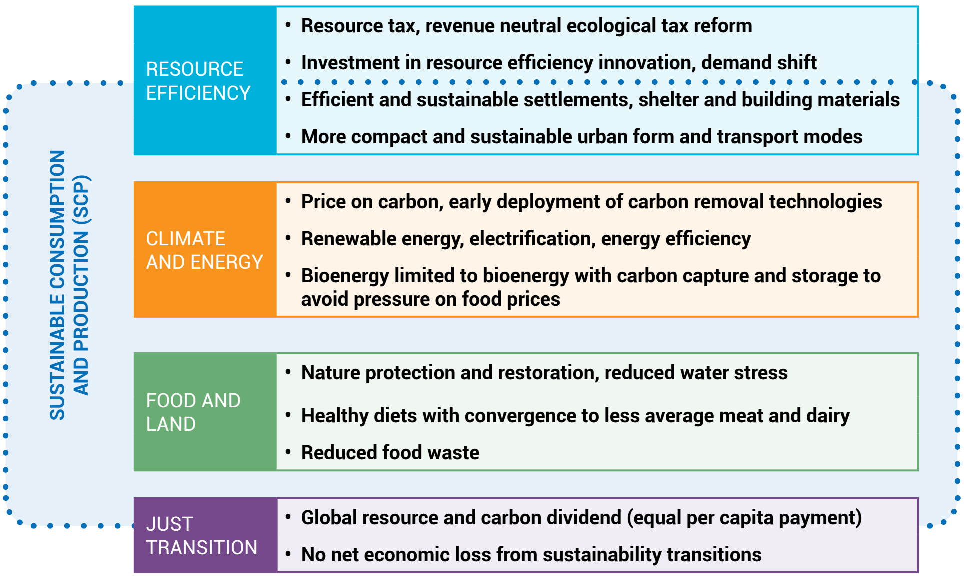


Figure 8: Summary of policy packages and societal shifts in the Sustainability Transition scenario for GRO24
Note: The no net economic loss measure is not fully implemented in the modelling.
(Source: GRO24 scenario modelling team)

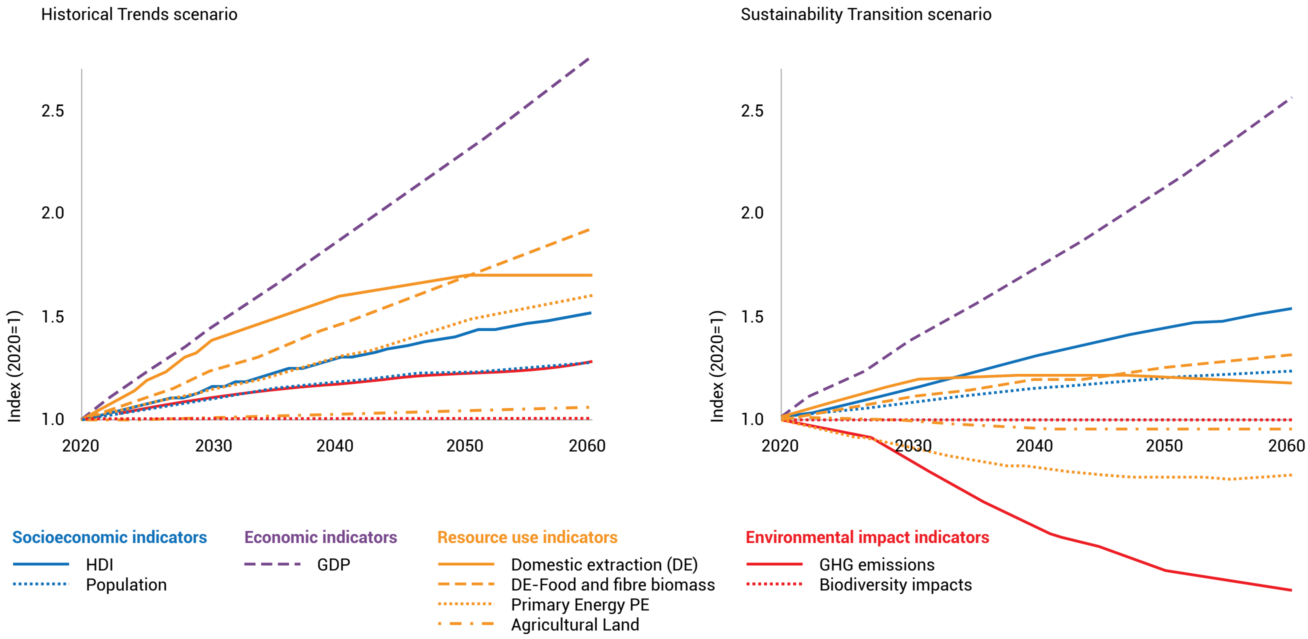


Figure 9: Global outcomes under Historical Trends (left) and Sustainability Transition (right) scenarios

Strong synergies were found between resource efficiency, GHG abatement and land use policies with resource efficiency contributing to achieving climate mitigation while reducing overall cost of the combined policy ambition. However, resource efficiency alone was not sufficient to bend the curve on resource use, and demand-side measures for resource intensive provisioning systems play an essential role in achieving the outcomes depicted in Figure 9.

The current modelling does not explore the full potential of circular economy policies. Scenarios which add ambitious resource recovery, recycling and other strategies to these policies would be expected to deliver larger improvements in resource efficiency than presented here. It is also important to note that while the package of resource efficiency measures implemented in the modelling boosts economic growth and provides net economic benefits, poorly designed and implemented strategies could slow growth and result in net economic costs.

Figure 9 and Figure 10 compare the outcomes of the two main scenarios, while the following section looks at some of the strategies that have been modelled as applied to resource-intensive provisioning systems and elucidates their potential outcomes.

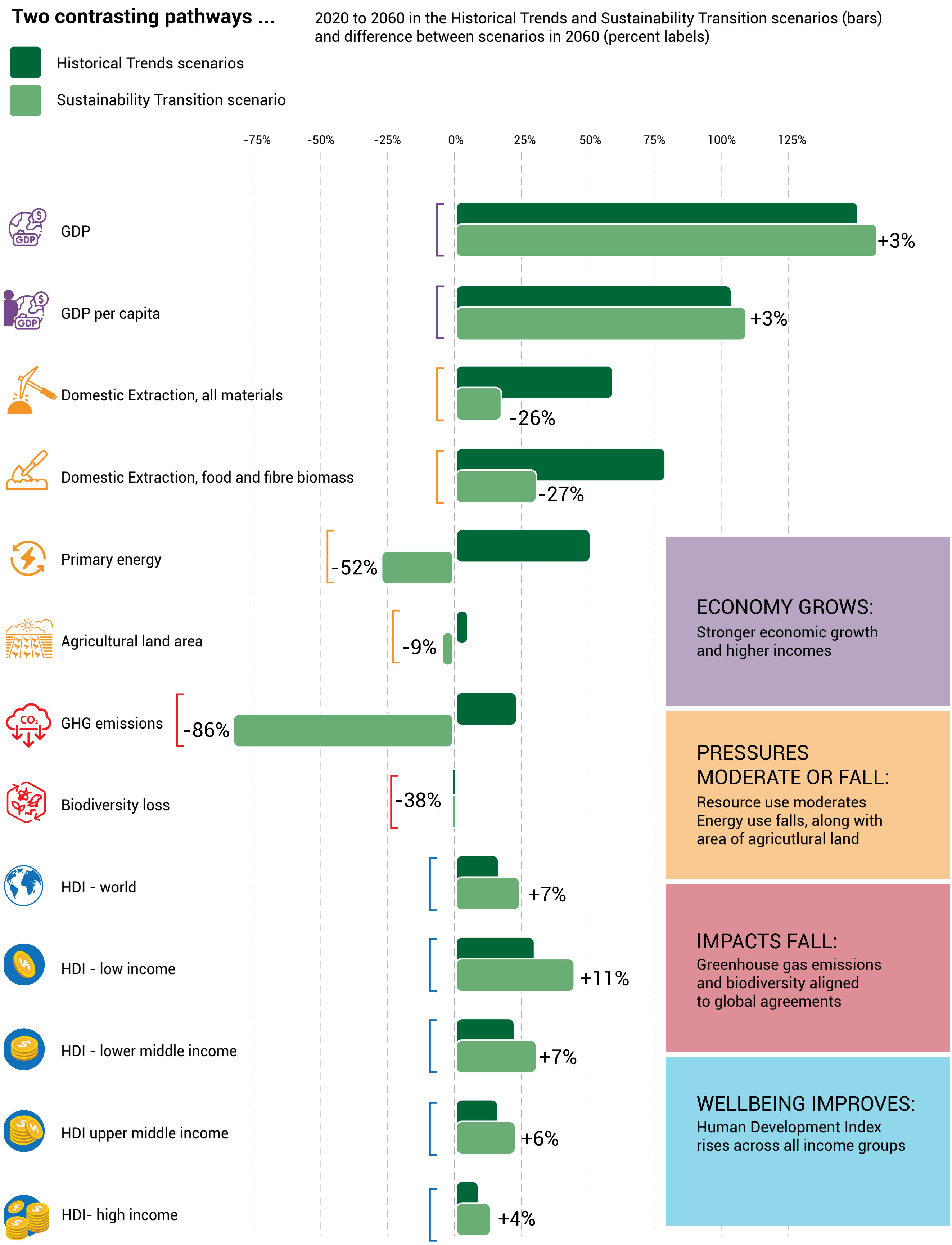


Figure 10: Towards Sustainability scenario sees higher growth and wellbeing, with lower resource use, environmental impacts and inequality than Historical Trends

Targeted strategies are needed to achieve better performing and resource-efficient provisioning systems

Overall, scenario modelling shows that all provisioning systems can become more resource efficient, with aggregate resource use increasing only for the food system, reflecting global population growth and increased food security (see Figure 11). Moving to low-impact, high-performing provisioning systems is an important element to deploy a transition towards sustainable resource use and ensure dignified living standards for all. Structurally lowering or avoiding resource intensive demand in high consumption contexts plays a particularly important role in transforming provisioning systems. The following sections look at the main strategies that were modelled for each of the four resource-intensive provisioning systems covered in the report and some of the outcomes that could be achieved.

Provisioning system	Food	Built environment	Mobility	Energy
Recommendations	• Reducing the demand of the most impactful food commodities • Reducing food loss and food waste • Protecting and restoring productive land while meeting demand for nutrition	• Assuring sustainability of the new building stock • Retrofitting the existing building stock • More intensive use of buildings	• Cities moving towards active mobility and public transportation • Reducing carbon-intensive frequent traveling modalities • Decreasing emissions intensity of transport modalities	• Decarbonizing electricity supply through the scaling up of low-resource renewable energies and increased energy efficiency
Outcomes from policies modelled in Scenarios	Can decrease the land needed for food by 5% compared to 2020 levels while more equitably ensuring adequate nutrition for all	Can decrease building material stocks by 25% by 2060, leading to a 30% decrease in energy demand, and 30% decrease in GHG emissions compared to current trends.	Can reduce related material stock requirements (-50%), energy demands (-50%) and GHG emissions (-60%) by 2060 compared to current trends.	Can drive a sharp decrease in energy demand, with reductions of climate impacts by more than 80 per cent.

Figure 11: Recommended strategies for reducing resource use across four provisioning systems, and expected outcomes based on scenario modelling

Assuring sustainability of the new building stock, retrofitting the existing building stock, more intensive use of buildings and decarbonization of material production

Compact and balanced neighbourhoods using more recycled building content, more intense use of buildings, lifespan extension and other circular economy measures can decrease building material stocks by 25 per cent by 2060. This can lead to a 30 per cent decrease in energy demand and a 50 per cent decrease in GHG emissions compared to following historical trends.

Over the last fifty years, the increase of the impacts of the built environment was mainly due to infrastructure build-up in Asia and is likely to be followed in other developing regions in the future. Sustainable construction and urbanization strategies are therefore urgently needed to avoid a further massive increase in climate and other impacts. This includes many strategies at policymaker disposal to reduce the material intensity of the built environment system. For instance, sufficiency strategies such as limiting floor area per person to a minimum that allows for decent living and more intensive use of buildings, or improved design for lower material and energy requirements. It also refers to increased lifespan of buildings and infrastructure, increasing content of sustainably produced timber as construction material – while considering that it is a limited resource – and the use of materials that store (biogenic) carbon over long periods of time.

The recommendations above are more relevant to countries in the process of developing their building stock, where providing quality housing for large numbers of citizens remains central to delivering on the SDGs. In these cases, the resource consumption will contribute to the build-up of the stock of such houses and dwellings. It is important that this happens with the principles of sustainable resource use at the core. For countries with older building stocks, regulation and incentives could be set up to accelerate the retrofitting rate of the existing stock of buildings, which is currently very low.[11]

Moving towards walking, cycling and public transportation in cities, reducing carbon-intensive frequent traveling modalities and decreasing emissions intensity of transport modalities

Enabling mobility through low-carbon public and shared transportation, walking and cycling can reduce related material stock requirements (-50 per cent), energy demands (-50 per cent) and GHG emissions (-60 per cent) by 2060 compared to current trends.

Solutions can reduce the demand for several forms of transportation through sustainable urban design, easily accessible services and, for example, teleworking from home. Solutions to make sustainable mobility accessible and available are critical to mitigate the resource use and impacts of this provisioning system. This includes designing mobility infrastructure for public and active (walking and biking) transport and shifting away from private vehicles. In addition to changing overall system design, classic resource efficiency measures also contribute to reduction in the mobility system's material demand: including vehicle light-weighting, more intensive vehicle use, extended vehicle lifespans and electrification of mobility. Together, these solutions can lead to reductions in mobility's material and energy demand by over 40 per cent by 2060 compared to continuing with current trends and policies.

These recommendations apply mostly to high-income and upper-middle countries, the biggest contributors to impacts from mobility. Emerging economies could avoid such inefficient land use planning modes and transportation infrastructure.

Reducing food loss, food waste and the demand for the most resource intensive food commodities (including animal-based products), whilst reducing, protecting and restoring productive land for maximum well-being and minimal impact

Demand-side measures such as dietary changes that lower consumption of high-impact commodities including animal protein and reducing food loss and food waste can decrease the land needed for food production by five per cent compared to 2020 levels while more equitably ensuring adequate nutrition for all.

To improve the sustainability of the food system, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP) all recommend removing subsidies and other incentives for consumption and production of animal-based products (UNEP 2022b). According to the IPCC (2022) agricultural subsidies can be moved away from the production of the commodities with the highest GHG emissions, such as beef.

11 IEA 2021b in UNEP 2022a state that retrofitting rate should be between 2.5 and 3.5 per cent every year, while current figure is below 1 per cent.

One way to make this change is to establish synergies with the human health agenda, since some of the most impactful commodities also have negative impacts on health (e.g. red meat or processed food). National dietary guidelines could be updated based on joint health and resource use considerations, referring also to the negative impacts of food overconsumption on health.

Decarbonizing electricity supply through the scaling up of low-resource renewable energies and increased energy efficiency, and decarbonizing fuels

As well as being directly used by households, energy supports other provisioning systems: a transition to sustainable resource use in the energy system would significantly contribute to the transition to sustainable mobility, built environment and food systems, and vice versa.

The transition to renewable energy needs to account for the massive increase of some key materials and the possible bottlenecks in material supply that this could lead to (Carrrara *et al.* 2023).[12] Accelerating the uptake of renewable energy could be based on technologies already mature enough to deliver at scale such as wind, solar and hydropower (IPCC 2022). Energies that are less intensive in terms of resource demand and related environmental footprint, such as wind and some kinds of solar energy, could be given priority. Investment is also needed in research and innovation of new renewable energy sources, electricity distribution systems and long-term power storage.

Avoiding future carbon lock-ins is critical (UNEP 2022a). This means that in parallel to boosting renewable solutions, it is essential to stop subsidies to fossil fuels production and investments in related infrastructure and energy-intensive industries. In addition, scaling up the use of low-carbon fuels could help transition sectors for which electrification is not yet feasible.[13] This will require decisive investment in innovation and could focus on green hydrogen (UNEP 2022a; UNEP 2022b) – an energy carrier useful for these applications yet of much lower efficiency – and bio-based solutions (IPCC 2023). Policies must be synergistic, monitored and evaluated to avoid rebound effects and unintended consequences.

Cross-cutting solutions are critical to enable a transition to sustainable resource use

The pathway towards sustainability is increasingly steep and narrow because much time has been lost and many policy commitments embedded in MEAs have not been delivered on. To deliver on decoupling, unsustainable patterns of resource use need to be reconfigured or replaced by sustainable modes of producing and consuming that respect the capacity of the planet, meet people's needs and improve human dignity. This calls for a process of structural transformation. To overcome barriers to transformation, policy must drive change and ensure the conditions needed to prompt systemic change in our systems of consumption and production.

Urgent action is needed now to institutionalise resource governance, including embedding resources in the delivery of multilateral environmental agreements on climate change, biodiversity loss, land degradation and others. Defining resource use paths aligned with the goals of these agreements and the creation of an international resource agency are some of the ways that resources could be prioritized at all levels of governance. Equally important is the reflection of the true costs of resources in the structure of the economy and the redirecting of finance towards sustainable resource use including through setting economic incentives correctly (including for example incentives addressing the rebound effect and subsidies reform including eliminating or repurposing environmental harmful subsidies). It is also essential to make trade and trade agreements engines of sustainable resource use, to mainstream sustainable consumption options, and to create circular, resource-efficient, just and low-impact solutions and business models. Making trade agreements engines of sustainability may involve reaffirming commitments to existing global environmental agreements within trade agreements; impact-related border adjustments and strengthened mandatory due diligence for traded commodities. Figure 12 outlines these critical recommendations for action that consider the multiple barriers to systemic transformation, refer to both consumption- and production-side actions, and go beyond optimisation and incremental improvements that have proved to be insufficient (too slow and not at scale).

12 For instance, for the case of the European Union, the renewable energy sector requires the biggest share of raw materials within the set of materials considered 'strategic'.

13 Even if demand is reduced to a minimum through designing other provisioning systems, some fuels will be still needed (e.g. for aviation, shipping, etc.). In addition, some energy-intensive industrial processes are very hard to decarbonize.

Such changes could provide an enabling environment that allows sustainable pathways based on well-being instead of material welfare, but they should be effectuated in a way that prioritises just outcomes. Specific instruments (for instance subsidies, taxes, nudges, infrastructure and planning) in line with often long-standing recommendations from global and regional bodies and scientific communities, must be adapted to regional and country governance backdrops.

While a number of policy recommendations of the report have been tried and tested and are well described in scientific and policy literature and practice, many uncertainties remain about the efficacy of policies. Innovative ways forward are also suggested, even of the type never attempted. While further assessment of the effectiveness of interventions both old and new is needed, the urgency of the triple planetary crises means action must proceed now based on the precautionary principle of evolving 'best available science'.

Institutionalizing resource governance and defining resource use paths

If we want to meet internationally agreed sustainability, climate and biodiversity goals and targets, integrating resource use better in international agreements, is a must. There is a need to explicitly recognize and integrate the use and production of resources at the core of the global sustainability agendas of climate, biodiversity, pollution and land degradation, and to acknowledge the role of resource use to meet existing multilateral environmental and sustainability goals. There are several levels and ways in which natural resource use can be integrated into global sustainability agendas, for example, monitoring of global resource use and regular benchmarking of countries regarding their resource consumption and productivity.

CRITICAL ASPECTS FOR TRANSITIONS	**Institutionalizing resource governance and defining resource use paths**	**Directing finance towards sustainable resource use**	**Making trade an engine of sustainable resource use**	**Mainstreaming sustainable consumption options**	**Creating circular, resource-efficient and low impact solutions and business models**
RECOMMENDATIONS FOR ACTION	• Global and national institutionalization of natural resource use within global sustainability agendas and environmental agreements • Definition of global and national resource use paths	• Internalizing the environmental and social costs of resource extraction • Redirecting, repurposing and reforming public subsidies for sustainable resource use • Channelling private finance towards sustainable resource use • Incorporating resource-related risk into Public and Central Bank mandates	• Innovation to multilateral, plurilateral and bilateral trade governance, including internalizing environmental and social costs and including provisions for sustainable resource use in agreements. • Enabling local resource value retention in producer countries	• Developing action plans to improve access to sustainable goods and services • Regulating marketing practices leading to overconsumption, and raising awareness	• Setting up monitoring and evaluation systems to identify priorities and develop ambitious circular economy action plans • Developing and reinforcing regulation to boost circular economy business models • Building circular economy capacity and coalitions

Figure 12: Critical aspects for the transitions towards sustainable resource use and recommendations for action

Under international agreements, countries could make national pledges for decoupling and develop action plans for implementation. Or countries could integrate resources considerations and solution pathways into nationally determined contributions under the UNFCCC, or national biodiversity action plans under the CBD, as already recommended by the G7 Berlin Roadmap (2022).

For such integration to happen, a better understanding of which resource use paths could meet the goals of these connected sustainability agendas is needed. Paths defined by targets have been widely used for environmental management and there are already many examples of resource-related targets around the world on which such resource paths could build. A more far-reaching proposal is the establishment of an International Mineral and Metals Agency as earlier proposed by IRP (2020a) Agency with a UNEA mandate as earlier proposed by IRP (2020).

Directing finance towards sustainable resource use

Current financial and economic structures are supporting the continuation of unsustainable patterns of consumption and production. Indeed, fossil fuels benefited from record subsidies in 2022 (IEA 2023; IMF 2023).[14] After decades of talking about harmful subsidies, it is essential to actually phase them out effectively and do it fast. This means redirecting, repurposing, reforming or eliminating economic incentives which contribute to unsustainable resource use and scaling up subsidies for sustainable resource use practices. All the while recognising that phasing out harmful subsidies have implications for livelihoods, so phase out would need to be accompanied by investments in local sustainable livelihoods and capacity building.

Public actors can channel private financial flows in the same direction. Financial regulators, including central banks and multilateral development banks, could work towards development of interoperable and compatible frameworks (classification systems, such as taxonomies) for financing sustainable resource use along the entire value chain. Central banks should make reducing resource-related risk a priority in their mandates – as some frontrunner central banks are doing for climate and biodiversity risks.

Regulation, including for example tax on impacts caused by virgin resource extraction, would help to incentivise the use of secondary materials and increased efficiency in production and to internalise environmental and social costs of resource extraction. However, examples of implementing resource taxes remain scarce and comprehensive feasibility assessments are currently lacking from the literature.

Making trade an engine of sustainable resource use

To respond to the challenge of making importing countries and the trading system more accountable and to maximize environmental and socio-economic benefits, there is scope for multilateral, plurilateral and bilateral trade governance (e.g. through the World Trade Organisation and regional trade agreements and organisations) to strengthen actions on improving the sustainability of resource flows and related measurements.

Changes to how trade is governed that recognise and reflect the (externalized) environmental and social costs of resource extraction could help extractors and producers to implement sustainable production practices. Incorporating these externalities would create a level playing field, preventing a 'race to the bottom' on environmental and social standards along resource value chains.

Trade governance innovations could include provisions for sustainable resource use in trade agreements including through reaffirming commitments to existing global environmental agreements within trade agreements; strengthened regulation of financial commodity markets, to minimize price volatility and protect access to basic commodities; implementation of impact-related border adjustment policy instruments that incorporate environmental impacts of resource extraction and processing into the cost paid for consumption; strengthened mandatory due diligence setting sustainable resource management standards for imported commodities; also those that enable local resource value retention in producer countries. In addition to the inclusion of appropriate provisions, the monitoring of their implementation is of key importance.

14 Subsidy amounts vary according to the method through which they are estimated, but major methods agree that 2022 was a record year for fossil fuel subsidies. IEA estimates US$1 trillion spent on fossil fuel subsidies. IMF subsidy estimates also include social and environmental costs, so are higher: IMF estimated US$7 trillion was spent on subsidizing fossil fuels in 2022. However, the fact that more was spent during 2022 than any other year was constant between both methods.

Mainstreaming sustainable consumption options

UNEP (2022b) calls for a "fair consumption space" that reduces consumption in higher income contexts, while also acknowledging the need to increase consumption for those who have yet to reach basic life standards. Moving to sustainable consumption requires intentionally shifting consumption patterns by disincentivizing highly resource-intensive options and scaling up goods and services that use fewer resources to satisfy human needs. To accomplish that, it is unrealistic to assume that citizens' consumption can be directed towards sustainable choices mainly through information and education while market signals and advertising push citizens strongly in unsustainable directions, and infrastructure to deliver sustainable mobility, housing, energy supply, etc. is lacking. Therefore, the focus needs to be put in rethinking how the current systems provide us with food, energy, mobility, and shelter, and how these provisioning systems are regulated, rather than placing the main responsibility of consumption choices on citizens. It is at the heart of systems approaches to shift incentives and outcomes at the level of system elements. Cross-cutting actions can help achieving this systemic change. This includes the development of country or regional level action plans to identify barriers that prevent sustainable consumption, identify consumption hotspots and their drivers and ensure access to sustainable options.

Disincentivizing and regulating out of the market resource-intensive options (like low-energy efficiency products or non-essential single use plastics) is another key mechanism to scaling up sustainable consumption. For effective implementation, attention to potential backlash from companies and citizens as well as to possible rebound effects is important. It is also critical to regulate marketing practices towards sustainable options, including business-to-consumer and business-to-business marketing, and covering both physical and e-commerce. Action on marketing practices – significant drivers of overconsumption – is also needed, such as banning green claims lacking evidence or making it compulsory for high-impact commodities to display information on their environmental footprint in particular resource (material, land and water) and climate footprints. Relying on sound environmental footprint estimates and transparent communication to the consumers is essential. Therefore, there is also a need to reinforce the capacity of national statistical offices, research institutes and global programmes working on sound data that can be used globally.

Creating circular, resource-efficient and low-impact solutions and business models

Further resource efficiency and reductions in material demand can be achieved by circular economy strategies, which include refuse, rethink, reduce, eco-design, reuse, repair, remanufacturing, refurbishment and recycling, among others. Such strategies allow maintaining the value of products and materials in the economy for longer, reducing the need for virgin material extraction and waste generation, and improving the management of waste. Further accelerating the uptake of the circular economy is needed, even for those considered frontrunners. Results so far are not meeting expectations and actions may not be prioritising the most impactful measures. Regulatory frameworks need to favour circular economy business models and promote the development of innovative approaches and demonstrative examples, which could then be scaled up. Improved monitoring and evaluation to identify the outcomes of implemented measures, what actions could be most effective, and to avoid rebound effects are critical.

The IRP material flows database provides examples of indicators that can be used to monitor the final outcomes of circular economy action plans: resource extraction, material consumption and material footprint and the derived indicators on resource efficiency. Additional metrics are also needed to better understand the internal metabolism of resources and identify hotspots and levers for action.

Building capacity and adapting skills to develop and scale up new practices, technologies and business models is required. Deploying resource efficiency and circular economy strategies is expected to increase jobs in the related sectors (Organisation for Economic Co-operation and Development [OECD] 2020). New skills will be needed to bridge the technology, labour and information requirements of new forms of processing materials and products. Less-industrialized countries could benefit from building on existing circular business models including those that have emerged in the informal sector (IRP 2018).

Call to action: Immediate and decisive action can transform resource use for the benefit of all

Far-reaching and systemic shifts in core resource intensive provisioning systems and resource governance systems have to be implemented at a scale and speed never tried before. The only choice is to stabilise and balance the human relationship with the rest of nature. Weak, partial, fragmented, or slow policies will not work. Leaders across all sectors, including government, business and civil society must act now. We can still make these changes and improve human well-being around the world, but the window of opportunity is closing.

The findings of the GRO 2024 are strongly aligned with the conclusions of recent reports from the IPCC, UNCCD, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Global Environment Outlook and World Health Organization, and are based on the efforts of global research communities in multiple fields and sub-fields. In fact, ever since the 1972 Conference on the Human Environment, the fundamental link between our impact as a society on the environment, our unsustainable use of resources, blatant inequality in the conditions for human development and the essential striving for a life in dignity have been connected, repeated (1992 UNCED, Rio+20 and Agenda 21 and the SDGs) and assessed.

This report is in fact, one more call, one more bundling of evidence and knowledge, adding to the growing body of scientific assessments in support of global sustainability agendas and the delivery of Multilateral Environmental Agreements. These assessments are to a very large degree aligned when it comes to conclusions and framing the necessary changes to our current economic and social development models to put us on a trajectory to sustainable development. Our report contributes knowledge on effective measures to control the driving forces of global degradation.

It is clear that without a much stronger sustainable resource use focus in major sustainability and Multilateral Environmental Agreements it will be impossible to reach the environmental and human development goals that are set. Scientists bring the best knowledge and illustrate potential pathways forward in increasingly bold manner. But it will be resolute political and boardroom decisions that change the direction of travel.

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