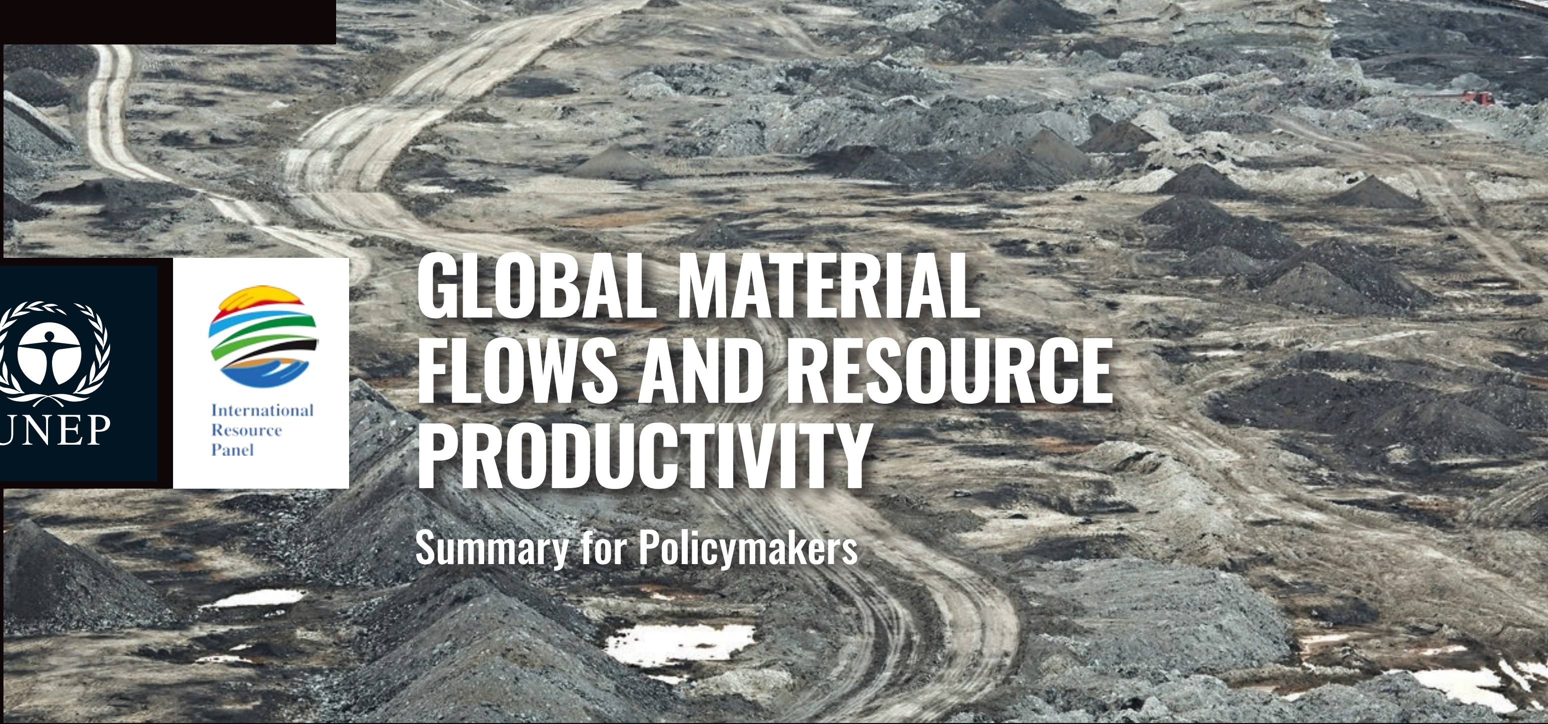

UNEP

International Resource Panel

GLOBAL MATERIAL FLOWS AND RESOURCE PRODUCTIVITY

Summary for Policymakers

UNITED NATIONS
ENVIRONMENT
PROGRAMME

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Global material flows and resource productivity

Summary for Policymakers

Produced by the International Resource Panel

This document highlights key findings from the report, and should be read in conjunction with the full report. References to research and reviews on which this report is based are listed in the full report.

The full report can be downloaded at http://www.unep.org/resourcepanel/Publications. Additional copies can be ordered via email: resourcepanel@unep.org, or via post:

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Preface

Janez Potočnik

Alicia Bárcena

In recent years, interest in resource efficiency and sustainable management of natural resources has increased considerably, standing out as one of the top priorities on the international political agenda.

With the historic adoption of the 2030 Agenda for Sustainable Development in September 2015 in New York, the international community committed itself to 17 Sustainable Development Goals to transform our world into a better place for current and future generations. It has been widely acknowledged that such a world can only be achieved and sustained if we better take care of, conserve and use natural resources and significantly improve resource efficiency in both consumption and production in the years to come. The SDGs emphasize the pressing need to decouple economic growth and human well-being from ever-increasing use of natural resources and related environmental impact.

As part of this historic recognition, the leaders of the G7, at their summit in Germany in 2015, decided to champion ambitious actions to improve resource efficiency as a core element of a broader strategy in pursuit of sustainable development.

All around the world, strategies and programmes that are mainstreaming sustainable natural resource management into national development plans are being designed and implemented. A growing number of countries are promulgating laws and regulations and implementing effective policy frameworks that support resource efficiency and guide investments into green and greening sectors of the economy.

Accurate, reliable data and scientific information are essential to economic planning and policymaking. Robust indicators are needed to measure progress with decoupling and resource efficiency and identify areas for improvement.

The International Resource Panel has produced several scientific assessment reports on resource efficiency and decoupling and is therefore in the perfect position to provide precisely such scientifically profound, policy-relevant information.

With this report, the Working Group on Global Material Flows of the International Resource Panel provides, for the first time, a comprehensive and harmonized data set of material use and movement in the global economy for the past 40 years. Based on this solid data set, it analyses status, trends, structure and dynamics of resource use, including extraction, trade and consumption of biomass, fossil fuels, metal ores and non-metallic minerals. The report finds that global material use has tripled over the past four decades, with annual global extraction of materials growing from 22 billion tonnes (1970) to 70 billion tonnes (2010).

The report also provides a new material footprint indicator, reporting the amount of materials that are required for final consumption, which sheds light on the true impact of economies. By relating global supply chains to final demand for resources, the indicator is a good proxy for the average material standard of living in a country. It indicates that the level of development and well-being in wealthy industrial countries has been achieved largely through highly resource-intensive patterns of consumption and production, which are not sustainable, even less replicable to other parts of the world.

Hence, decoupling material use and related environmental impacts from economic growth is essential for ensuring the prosperity of human society and a healthy natural environment. But in order to be successful, decoupling efforts need to go beyond simple efficiency gains that arise from maturing economies.

This report also shows that consumption is the main driver of increased material use, more important than population growth in recent decades. With millions of people lifted out of poverty and a rapidly expanding middle class in the coming decades, a prosperous and equitable world calls for transformative changes in lifestyles and consumption behaviour.

The findings of this report have the potential to contribute significantly to many national and regional natural resource management and resource efficiency efforts and are particularly relevant for the implementation and monitoring of all decoupling-related Sustainable Development Goals over the next 14 years.

The International Resource Panel is committed to continuing to provide cutting-edge scientific knowledge on sustainable resource management and resource efficiency. We are very grateful to Heinz Schandl and Marina Fischer-Kowalski and their co-authors for their important contribution to the understanding of global material flows and resource productivity, and we are very much looking forward to the response of policy-makers and business leaders to the tremendous challenges, opportunities and implications highlighted in this report and data set.

Foreword

Ibrahim Thiaw

Natural resources provide the foundation of our lives on Earth. Water, soil, energy, minerals and metals underpin our standards of living. They feed and shelter us, and provide for our material needs throughout our lives.

Yet pressures on these natural resources are mounting. A growing population and heightened world economic demand in the past half century are rapidly depleting these vital resources, inflicting great harm on the natural environment and human health. In our ever-more globalized economy, sustainable management of natural resources will become increasingly important.

When the world's nations approved the Sustainable Development Goals in 2015, they set out a path towards solving some of these great challenges. These ambitious goals aim to eradicate poverty and sustain economic growth, while maintaining the natural resource base and planetary ecosystems for future generations. Turning the goals into reality will require concerted action by the entire world, developed and developing countries alike. For these reasons, we must better understand where and how natural resources are used.

This latest report from the International Resource Panel, Global Material Flows and Resource Productivity, provides a comprehensive, scientific overview of this important issue. It shows a great disparity of material consumption per capita between developing and developed countries. This has tremendous implications for achieving the SDGs in the next 14 years.

Global material use has been accelerating. Material extraction per capita increased from 7 to 10 tonnes from 1970 to 2010, indicating improvements in the material standard of living in many parts of the world. Domestic extraction of materials has grown everywhere to meet increased demand for materials. However, Europe and the Asia-Pacific region have not met all of their material demand from domestic extraction and have increasingly relied on large imports. Trade in materials is thus booming, driven mainly by consumption.

The report also lays bare the large gaps in material standards of living that exist between North America and Europe and all other world regions. Annual per capita material footprint for the Asia-Pacific, Latin America and the Caribbean, and West Asia is between 9 and 10 tonnes, or half that of Europe and North America, which is about 20 to 25 tonnes per person. In contrast, Africa has an average material footprint of below 3 tonnes per capita. Such a distribution of materials supports unequal standards of living and highlights how much work will be needed to achieve sustainable development for all.

It is my sincere hope that the findings of this important assessment will inspire political and business leaders to take the action needed to achieve the SDGs.

I would like to express my gratitude to the International Resource Panel, under the leadership of Janez Potočnik and Alicia Bárcena, for developing this substantial report.

Ibrahim Thiaw

United Nations Assistant-Secretary-General and UNEP Deputy Executive Director

Contents

Introduction

Measuring economic activity at aggregate and detailed levels through the System of National Accounts is a standard activity undertaken by every country. A new study by the United Nations Environment Programme (UNEP) International Resource Panel provides, for the first time, a coherent account of material use in the global economy and for every nation, which is complementary to the System of National Accounts. The study reports material extraction and trade of materials to provide an authoritative database and indicators that can be used by the policy and business communities to monitor the supply and demand of materials. The study is supported by an extensive database covering 40 years of the extraction, trade and consumption of biomass, fossil fuels, metal ores and non-metallic minerals. The database and related indicators can also support the implementation of the Sustainable Development Goals global indicator framework, particularly by helping to measure SDG targets 8.4 (resource efficiency in consumption and production), 12.2 (sustainable management and efficient use of natural resources), and 12.5 (waste reduction). The data are made available through the UNEP online data portal UNEP Live **http://uneplive.unep.org/** and on the International Resource Panel (IRP) website **http://www.unep.org/resourcepanel/**.

Most economic activity depends, to a varying extent, on the supply of materials and other natural resources such as energy, water and land. A growing world economy requires more materials for production and consumption, which results in a variety of environmental impacts including natural resource depletion, waste and emissions, and climate change. In a global context of growing population and per capita consumption, economic planning and policymaking require additional information on material extraction and trade to accompany standard national accounting. Such information allows assessment of material productivity at global, regional and country levels.

Trends and improvements in material productivity show the combined effect of innovation and technological change and policy for resource efficiency and sustainable consumption and production. It is now commonly understood that fuelling the aspirations of a growing global population – the provision of housing, mobility and food, electricity and water and modern consumer goods – will not be possible without very large improvements in the material and energy efficiency of the global economy. The new information provided in this study will help identify opportunities, risks and vulnerabilities related to the global supply of raw materials and show the potential for efficiency gains and reductions in material use in the global economy.

Resource efficiency has taken centre stage in the international policy debate

The notion of resource efficiency and the need to improve the value economies generate per unit of material use has truly been embraced by the international policy community.

The United Nations 2030 Agenda for Sustainable Development and its 17 SDGs, which were agreed universally by all United Nations member countries in September 2015, state that sustainable natural resource use and management are a necessary condition to achieve a better future for current and future generations. Sustainable Consumption and Production (SCP), decoupling, resource efficiency and waste minimization (the 3Rs – reduce, reuse, recycle) are featured in the Agenda as stand-alone goals or targets. The compelling need to decouple economic growth and human well-being from ever-increasing consumption of natural resources is therefore now very evident in policy discussion and many countries have initiated policies to facilitate decoupling of material use from economic well-being.

In addition, the leaders of the Group of 7 (G7) met in Germany in June 2015 and decided on ambitious action to improve resource efficiency as a main element of a broader strategy to promote sustainable materials management and the circular economy.

A number of countries have spearheaded the need for greater resource productivity and reduced material use per unit of economic growth as part of their economic development strategies and plans. Most notably Japan, the European Union and China have instituted high-level policy agendas for reducing material extraction and use and increasing the circular behaviour of their economies through remanufacturing, recycling and reuse. Japan's Sound Material Cycle policy objective, the European Strategy for Sustainable Natural Resource Management and the Chinese circular economy promotion law are key examples of the growing interest in resource efficiency and sustainable materials management.

Decoupling is the imperative of modern environmental policy

Decoupling material use and environmental impacts from economic growth is a strategy that will be essential for ensuring future human well-being based on much lower material throughput. Many regions and countries have embarked on strategies to substantially increase the material efficiency of their economies and to reduce overall levels of material use. The European Union, Japan and China, among others, now have high-level policy frameworks and laws that support resource efficiency and guide investments into green sectors of the economy supported by sustainable consumption and production practices. Increasingly, developing countries are mainstreaming SCP and green economy policies into their national development plans acknowledging the need to decouple their human development efforts from ever-increasing natural resource use, emissions and waste. UNEP and the IRP are providing independent, coherent and authoritative scientific assessments of policy relevance on the sustainable use of natural resources and, in particular, their environmental impacts over the full life cycle; and contributing to a better understanding of how to decouple economic growth from environmental degradation. This information allows countries to inter alia monitor progress of their efforts to reduce material throughput and improve the material efficiency of their economies.

A degree of success in decoupling economic activity from material use occurs spontaneously as economies mature and move to economic activities that have a lower material intensity and provide higher salaries and revenues. Decoupling needs to go beyond efficiency gains which come as a free dividend of structural change. In doing so it will be possible to service the needs and aspirations of a growing global population and fast-increasing world economy within the limits of available natural resources and ecosystems. **The technological potential for decoupling is large and the economic benefits are substantial. There are many cost-effective ways for decoupling in the short and medium terms and in the long term decoupling will generate much higher economic returns than business as usual**.

In this report we measure resource productivity in two ways. Firstly through the material intensity of national economies as territorial material use per unit of GDP, and secondly through material consumption per unit of GDP.

Global material use has accelerated

Global material use has grown strongly over the past four decades, and has accelerated since the year 2000 at a time when economic growth and population growth have been slowing. Overall, the global economy expanded more than threefold over the four decades from 1970 to 2010, population almost doubled and global material extraction tripled. The world economy has experienced a great acceleration in material use since 2000, strongly related to the industrial and urban transformation in China and many other emerging economies, which has required unprecedented amounts of iron and steel, cement, energy and construction materials. Growth in material demand in Asian emerging economies since the year 2000 has reverberated across the world economy, especially in primary material exporting regions and countries such as Latin America, Africa and Australia.

Annual global extraction of materials grew from 22 billion tonnes in 1970 to around 70 billion tonnes in 2010 and non-metallic minerals used in construction was the fastest growing group of materials.

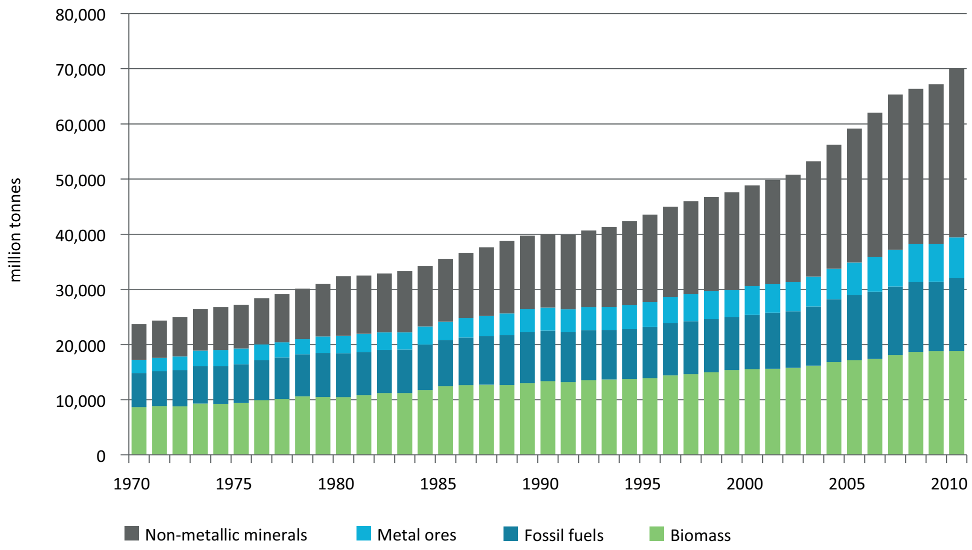

Figure 1. Global material extraction (DE) by four material categories, 1970–2010, million tonnes

There has been a close relationship between economic trends and natural resource use over the past four decades. Global material demand slowed in 2008 and 2009 due to the global financial crisis, with trade flows sharply contracting in 2009, but is again on a growth trajectory. Sustained reductions in material use depend on changes in the structural asset base of an economy. Buildings, transport and communication infrastructure, energy generation capacity and water supply systems as well as manufacturing infrastructure require a certain level of material use to fuel current systems. This means that there is considerable inertia built into the global system of material use, making it difficult to reduce material use rapidly and on a sustained basis.

Growth in global material extraction was such that per capita global material use increased from 7 tonnes per capita in 1970 to 10 tonnes per capita in 2010, a result of improvements in the material standard of living in many parts of the world. Domestic extraction of materials has grown in all world regions to meet the increased demand for materials. On a per capita level, material use has declined in some regions, including Europe and North America, especially since 2008. Asia and the Pacific has experienced the fastest growth, increasing its global share of material use from around 25% in 1970 to above 50% in 2010. Asia and the Pacific was the only region which did not experience a decline in material use during the financial crisis.

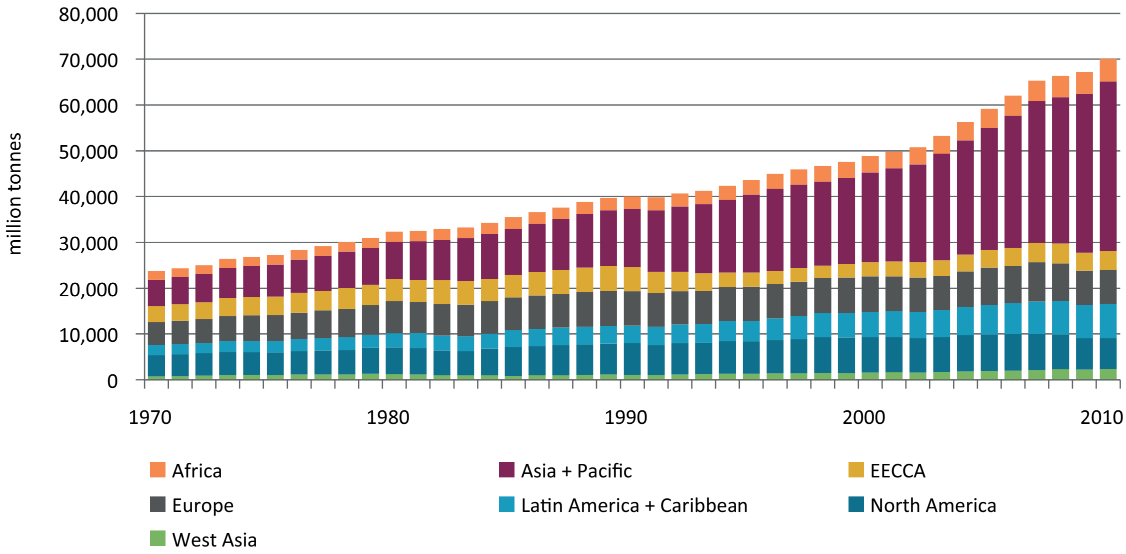

Figure 2. Domestic extraction (DE) by seven subregions, 1970–2010, million tonnes

The densely-populated global regions of Europe and Asia and the Pacific (and to some extent also North America) have not been meeting all of their material demand from domestic extraction of natural resources, despite large increases in agricultural production and mining in Asia and the Pacific, especially. These regions have **required large and increasing amounts of imports of materials**, especially fossil fuels and metal ores, but also increasingly agricultural products, from all other regions.

Trade in materials has grown dramatically and mobilizes much greater amounts of materials than direct traded flows indicate

Trade has grown faster than domestic extraction and direct trade in materials has expanded fourfold since 1970. In 2010, more than 10 billion tonnes of materials were exported globally. Fossil fuels comprised the largest share of exports, well ahead of metal ores and biomass. Per capita global exports of materials doubled from 0.8 tonnes per capita in 1970 to 1.6 tonnes per capita in 2010.

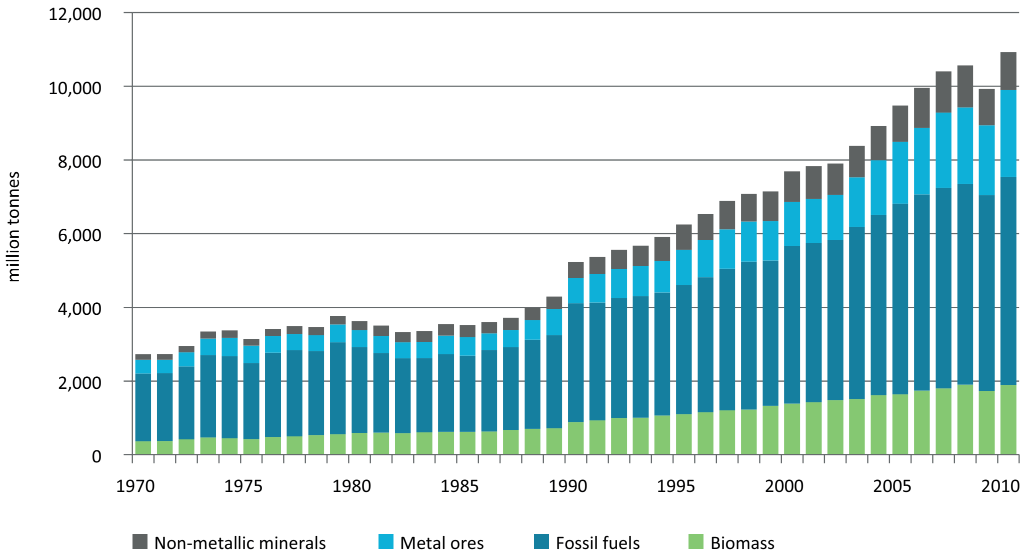

Figure 3. Global exports of materials by four material categories, 1970–2010, million tonnes

Trade is responsible, however, for much larger amounts of material extraction when the whole life cycle of traded products is considered. Accounts of the raw material equivalents of direct trade of materials show the real contribution of trade to material exploitation. **The new indicators of raw material equivalents of imports and exports show that trade mobilizes much greater amounts of materials than direct traded flows indicate**. In 2010, 30 billion tonnes of materials extracted globally were required to produce 10 billion tonnes of directly traded goods. A raw material trade balance based on the attribution of globally extracted materials to traded goods shows that only Europe and North America have remained net importers of materials. By contrast, the Asia-Pacific region has changed into a net exporter of materials through large exports of manufactured goods which are mostly consumed in Europe and North America.

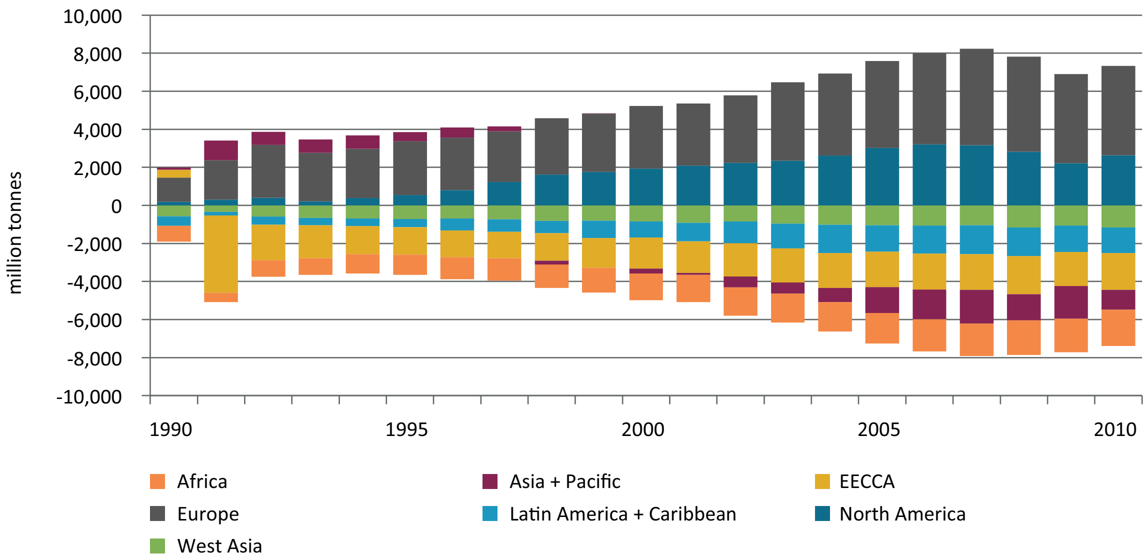

Figure 4. Raw material trade balance (RTB) by seven subregions, 1990–2010, million tonnes

Over the four decades an increasing specialization of countries with regard to natural resource extraction for trade emerged, especially for fossil fuels and metal ores but to some extent also for agricultural products. This is especially visible at the country level where countries such as Australia, Brazil, Chile, Indonesia and Kazakhstan, among others, have increased their net exports of materials over time while other countries such as South Korea and the United States (until 2005) increased their net imports of materials, or depended (such as Germany, France and Japan) on a high level of net imports over the four decades. China, India and Pakistan show an interesting pattern of fast-increasing import dependency for the direct trade of materials which coincides with the status of a net exporter when adjusting trade flows for upstream and downstream indirect material flows associated with trade, i.e. looking at the raw material equivalents of trade.

This increasing specialization has created very different environmental and social issues in countries which are net exporters or net importers of materials. It also creates a different policy context for sustainable natural resource use and decoupling of economic growth from material use. Importing countries have strong incentives to invest in material efficiency strategies and policies to increase their economic resilience. Such policy efforts are not matched by exporting countries. Both types of countries are affected by global resource price changes but in very different ways. Countries relying on material imports profit from low world market prices and their economic performance is harmed by high prices. Material exporters make windfall gains when natural resource prices are high but experience a hit to their balance of trade when prices fall and production contracts; these effects have been experienced since about 2014 in commodity-exporting regions including Latin America, Africa and Australia.


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Consumption has been the main driver of growing global material use

Globally, growth in per capita income and consumption have been the strongest drivers of growth in material use, even more important than population growth in recent decades, but certainly since 2000. Population has continued to contribute to rising material demand but not to the same extent as rising per capita income and the emergence of a new middle class in developing countries. Millions of people have been lifted out of poverty over the past four decades and a fast-growing middle class in many developing parts of the world has resulted in changes in lifestyles, aspirations and consumption behaviours. The new consumers require products and services that have a higher material intensity and their sheer growth in numbers has ratcheted up global material requirements.

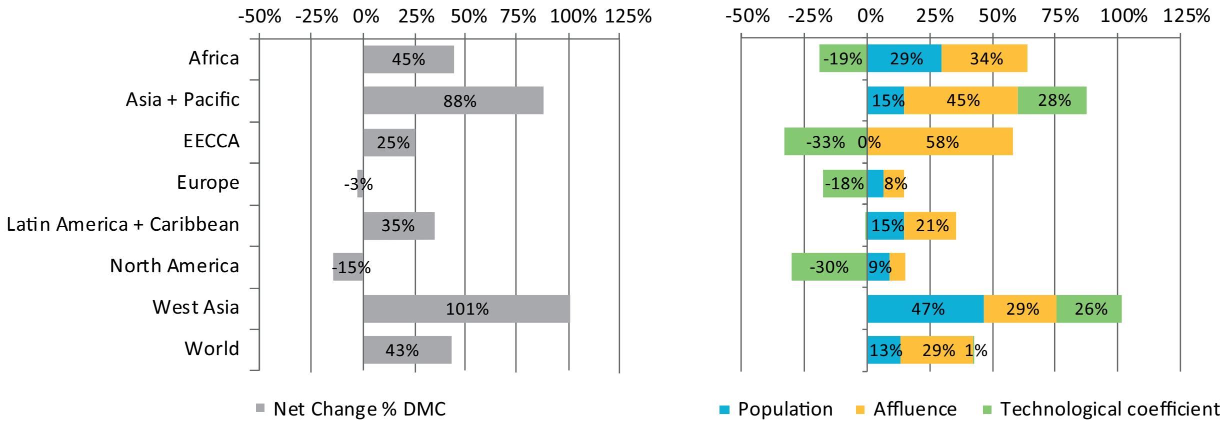

Figure 5. Drivers of net change in domestic material consumption between 2000 and 2010 for World regions: population, affluence, and material intensity

Material efficiency mitigated some of the growth of material use driven by growing population and consumption between 1970 and 1990. Since 1990, there has not been much improvement in global material efficiency, which actually started to decline around the year 2000.

Production has shifted from very material-efficient countries to countries that have lower material efficiency, which has resulted in an overall decline in material efficiency

Countries earn a material efficiency dividend as their economies mature. Most countries have improved their material productivity over time, i.e. they use less material per unit of GDP. They have followed this path over the past four decades with the exception of a number of resource-exporting countries whose material intensity has been stable. Despite this, global material productivity has declined since about the year 2000 and the global economy now needs more materials per unit of GDP than it did at the turn of the century. While this may seem counter-intuitive it has been caused by a **large shift of economic activity from very material-efficient economies such as Japan, the Republic of Korea and Europe to, at this time, the much less material-efficient economies of China, India and Southeast Asia**.

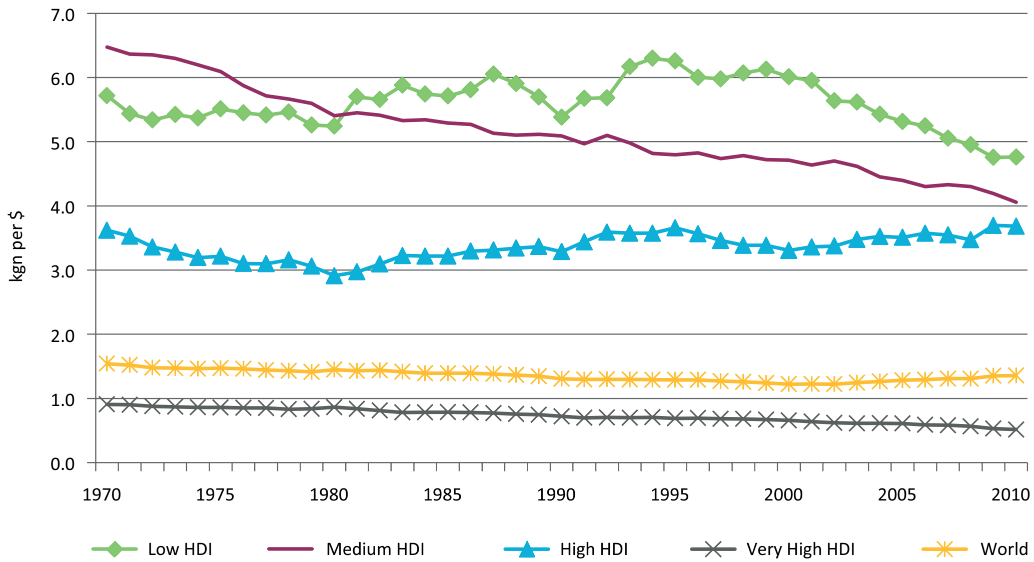

Figure 6. Material intensity (DMC per unit of GDP) by development status and global material intensity, 1970–2010

This results in overall growing environmental pressure per unit of economic activity and shows that additional effort around public policy and financing is required to improve material use efficiency substantially in the coming decades.

Increasing the efficiency of material use in the global economy will not happen spontaneously but will require well-designed policies that change incentives for businesses and for corporate and government consumers. The high level of well-being in many industrial countries has been achieved by policy settings that allowed labour productivity to grow often at the cost of growing material use and waste. To allow general well-being for a large number of people by 2030 requires substantial changes.

Large investment into research and development would enable fast-increasing material efficiency in many sectors of the economy. A rise in the efficiency of material use will, however, lead to lower costs for producers and consumers and the money saved on primary materials will be invested and spent elsewhere in the economy. This will cause a rebound effect where efficiency will allow for higher economic growth and perhaps contradict efforts to reduce overall material demand. **Achieving human development and improved well-being at lower levels of material consumption will require a complex policy mix of resource efficiency investments and incentives, a price on primary material at extraction and a shift to shorter working hours, i.e. compensating productivity gains with more free time to offset rebound spending.**

The level of well-being achieved in wealthy industrial countries cannot be generalized globally based on the same system of production and consumption

The IRP has adopted a new indicator, the material footprint of consumption (Wiedmann et al. 2015). Material footprint reports the amount of materials that are required for final demand (household and government consumption and capital investment) in a country or region. By relating global supply chains of materials to final demand this indicator is a good proxy for the average material standard of living achieved in a country.

The current global system of production, based on particular supply chains and technologies, results in a material footprint of Europe's consumption of around 20 tonnes per capita and a material footprint of North America's consumption of around 25 tonnes per capita. Both regions have experienced a decline in material footprint since 2008 caused by the economic downturn during the global financial crisis (GFC). Before the GFC, North America had a per capita material footprint of well above 30 tonnes and Europe of well above 20 tonnes, and both regions were on an upward trajectory. It remains to be seen whether the economic recovery in North America and Europe has put material footprint on a growth trajectory again. **If the material footprint were to return to pre-GFC levels in the wealthiest parts of the world it would suggest that there is no level of income yet at which material use has stabilized**.

The material footprint indicator allows, differently from measures of material extraction and direct material use, the establishment of a landing point for industrial material use. The available data suggest that industrial metabolism of modern industrial economies stabilizes at between 20 and 30 tonnes per capita for the current ways in which we build houses and transport infrastructure, how we organize mobility, and how we deliver manufactured goods, food and energy. Given the fact that the global economy, at today's level of resource use, is already surpassing some environmental thresholds (planetary boundaries), this shows that the level of well-being achieved in wealthy industrial countries cannot be generalized globally based on the same system of production and consumption. **Large improvements in decoupling are required to service the needs and aspirations of a growing global population in an inclusive way**.

To reduce environmental pressures and impacts of consumption and production, high-income countries will need to substantially decrease their current per capita material footprint. Many developing countries, on the other hand, will see their material footprint rise as living standards improve. Policy settings in countries that grow their infrastructure and consumption substantially need to be tailored towards achieving rapid and short-term gains in resource efficiency to offset some of the growth and to build cities and infrastructure in way in which natural resource requirements, waste and emissions can be minimized. **There is a large window of opportunity for policy settings that support investment in high-quality and long-lasting infrastructure to support sustainable development**.

The richest countries consume on average 10 times as many materials as the poorest countries

There is still a large gap in the average material standard of living and resulting material footprint between North America and Europe and all other world regions. The annual per capita material footprint for Asia and the Pacific, Latin America and the Caribbean, and West Asia in 2010 was between 9 and 10 tonnes, or half the per capita material footprint of Europe. The EECCA region follows with 7.5 tonnes per capita and Africa, on average, has a material footprint of below 3 tonnes per capita.

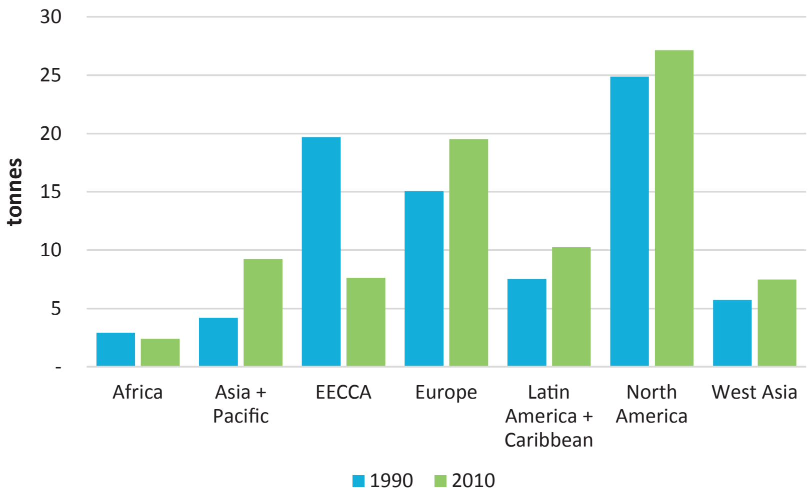

Figure 7. Per-capita material footprint (MF) by seven world regions, 1990 and 2010, tonnes

These results are confirmed when we look at the relationship between human development and material footprint, where very high human development as measured by the human development index (HDI)[1] required around 25 tonnes of material footprint and was rising before the GFC. The group of countries achieving high human development have experienced the fastest growth in material footprint and are now averaging 12.5 tonnes per capita, up from 5 tonnes per capita in 1990. China, for instance, had a material footprint of 14 tonnes per capita in 2010 on a strong upward trajectory and Brazil had a material footprint of 13 tonnes per capita in 2010 and has also grown strongly in recent years.

The average material footprint of countries with medium levels of human development has grown slowly over the past two decades, reaching 5 tonnes per capita, while material footprint in low HDI countries has been stagnant for the past two decades at 2.5 tonnes per capita. **The wealthiest countries consume on average 10 times as many materials as the poorest countries, and twice the world average, which demonstrates very unequal distribution of materials to support the standard of living. It shows that the low income group of countries will require increasing quantities of materials, per capita, to achieve the sustainable development outcomes the global community aims for**.

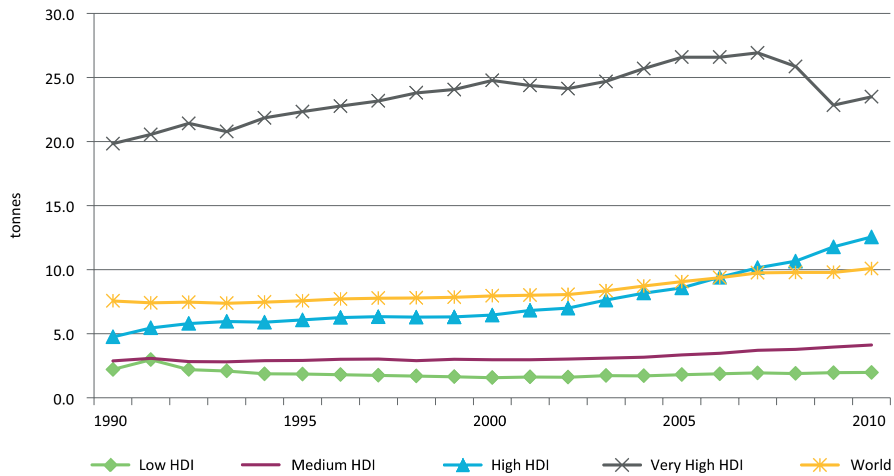

Figure 8. Per capita material footprint (MF) by HDI level, 1990–2010

[1]The HDI is a compound index on life expectancy, literacy and income; see http://hdr.undp.org/en/content/human-development-index-hdi

A new comprehensive database for global material flows is available

The IRP provides a comprehensive understanding of linkages between the world economy, population and material use for over four decades (1970–2010) based on a new and authoritative database of global material extraction and a revised database for materials trade. It uses a standard set of material flow accounting indicators as well as new indicators. The data and indicators presented by the IRP will allow countries and regions to monitor their progress in achieving greater material efficiency through well-designed national policies and regional initiatives. A large data set covering 40 years (1970–2010) and most countries of the world has been established. It presents direct and consumption-based material flow indicators for seven world regions and for individual countries, covering total usage, per capita use and material use per US$. It also provides details for different groups of materials and relates indicators to human development outcomes.

It provides similar information for each of seven world regions and about 180 countries to support informed decision-making by policy and business communities. The outlook is for further growth in material use if countries successfully improve economic and human development and are able to raise living standards and combat poverty. **Assuming that the world will implement similar systems of production and provision for major services – housing, mobility, food, energy and water supply – nine billion people will require about 180 billion tonnes of materials annually by 2050 (Schandl et al. 2016), almost three times today's amounts**. This will result in faster exploitation of natural resource endowments and increased environmental impacts related to material extraction and use.

In this report, the use of materials – society's metabolism – is interpreted as an environmental pressure. The larger the material use the bigger the pressure. Material use is also closely related to other pressure indicators including waste flows, energy use and carbon emissions, land use and water use. When material use grows, ceteris paribus, other pressure indicators will increase. Material use is also used as a proxy for environmental impacts that occur across the whole life cycle of material use from extraction, transformation and consumption to disposal. When material use increases, the environmental, social and economic impacts of material use also see a commensurate rise. **Rising material use will result in climate change, higher levels of acidification and eutrophication of soils and water bodies, increased biodiversity loss, more soil erosion and increasing amounts of waste and air pollution. It will also have negative impacts on human health and quality of life. It will ultimately lead to the depletion of certain natural resources and will cause supply shortages of critical materials in the short and medium terms**.

While many resources will still be abundantly available over the medium and long terms, pollution and ecosystem degradation and a changing climate will dominate political debate around using materials more effectively and efficiently. Fast-expanding demand for materials will, however, require very large investments into new extraction and supply infrastructure and will possibly contribute to local conflict over alternative uses of land, water, energy and materials. Such conflict is already pronounced in the energy sector where mining competes with agriculture and urban development in many places.

Indicators can be created from material flow accounts

The data set presented by the IRP is based on international agreements and methodological standardization arrived at over the last two decades (Fischer-Kowalski et al. 2011). Based on the material flow data and additional empirical analysis, indicators for direct material use and for whole of life cycle material requirements of trade have been established. The headline indicators describe different aspects of the physical economy and are summarized in Table 1.

Different headline indicators, as well as the more detailed information available for each headline indicator, provide information for different policy domains and cover all aspects of the environmental pressure of material use. They include natural resource depletion locally and in the global economy, resource efficiency, and waste management and waste minimization. They track the performance of a national economy with regard to their success in sustainable materials management, resource efficiency and waste minimization.

TABLE 1. HEADLINE INDICATORS

INDICATOR NAME	MEANING OF INDICATOR	DISAGGREGATION
Domestic extraction of materials (DE)	Domestic extractive pressure on natural resources	44 material categories
Imports of materials (Imports)	Direct imports	11 material categories
Domestic material input (DMI), i.e. DE plus Imports	Material requirement of production	11 material categories
Export of materials (Exports)	Direct exports	11 material categories
Physical trade balance (PTB), i.e. Imports minus Exports	Direct trade dependency	11 material categories
Domestic material consumption (DMC), i.e. DE plus PTB	Territorial material use and long-term waste potential	11 material categories
Raw material equivalents of imports ($RME_{Imports}$)	Upstream material requirements of imports	4 material categories
Raw material equivalents of exports ($RME_{Exports}$)	Upstream material requirements of exports	4 material categories
Raw material trade balance (RTB), i.e. $RME_{Imports}$ minus $RME_{Exports}$	Trade dependency of consumption	4 material categories
Material footprint of consumption (MF), Raw material consumption (RMC), i.e. DE plus RTB[2]	Global extractive pressure on natural resources of consumption	4 material categories
Material intensity (MI), i.e. DMC per US$	Efficiency of material use	1 category
Adjusted material intensity (AMI), i.e. MF per US$	Efficiency of material use corrected for trade	1 category

[2] MF and RMC are identical measures of the raw material requirement of final demand of a country. Both terms are used in the peer-reviewed literature. The first refers to the conceptual relationship with other footprint accounts for energy, carbon emissions and water; the latter relates to the conceptual language of material flow accounting.

Providing information on the sustainable development goals

The SDGs comprehensively address the natural resource underpinnings of economic growth and human development across all aspects of resource use. Goal 6 is concerned with water use, goal 7 with energy, goal 12 with materials and waste and goal 13 with carbon emissions and climate change. Very importantly goal 8, which has a focus on economic growth, specifically addresses resource efficiency in target 8.4. This target asks countries to continuously improve their resource efficiency of production and consumption over time.

The data and indicators presented in the IRP study provide pressure indicators for a number of targets of the SDGs, including targets 8.4, 12.2 and 12.5. The pressure indicators can be linked to drivers of environmental change such as economic growth, poverty reduction and universal access to many goods and services.

Target 8.4 asks for a ratio between a pressure (material use) and driver (GDP) for production and consumption. The first can be expressed as domestic material consumption (DMC) per unit of GDP, the latter as material footprint (MF) per unit of GDP.

Target 12.2 asks for a measure of metabolic performance at the national economy level and can be expressed as DMC per capita and MF per capita, reflecting both production and consumption perspectives.

Target 12.5 is about waste reduction and can be expressed as domestic material consumption (DMC) per unit of land area to demonstrate the ecological pressure of waste disposal.

Because the data are available for most countries globally they can readily be used to report against these very relevant targets of the SDGs to demonstrate the extent to which material use and material footprint have contributed to the economic development of countries and to monitor improvements in the material intensity of economic activity in a country. This also provides information on future material requirements of a global economy that will service 9 billion people, including a fast-growing urban and middle class population, and will allow governments to set targets for material use and material efficiency.

For many developing countries achieving the SDGs will require increases in natural resource use, waste and emissions. This may ultimately overstretch natural resource supply systems and the absorptive capacity of ecosystems for waste and emissions. To make space for human development needs, governments and businesses need to work together to achieve sustainable consumption and production. This will allow high-income countries to reduce their currently very high material use and developing countries to increase their material use so that they converge at a sustainable level.

Next steps

The work of the IRP in the domain of material use and resource productivity is a first step towards harmonizing global data sets and establishing material flow satellite data at national and global levels. Because of the increasing natural resource, waste, and emission pressures of global economic development the knowledge base needs to grow further.

Extending and further developing the accounts

The IRP has successfully cohered the existing global knowledge base on material flows and provided time series for four decades (1970–2010) on material inputs and trade of materials. The data set needs to be extended in scale by providing periodic and timely updates to the existing time series. The assessment needs to be extended at the back end of the material cycle to report outflows to different environmental media – air, soil and water – and to close the material balance of national economies and at the global scale. This will allow better understanding of the material stock that services the global economy, the relationship between existing assets and flows and the long-term waste and emission potential of the global economy.

Focusing on economic sectors

Material flow data sets are structured by material characteristics but lack sufficient sectoral detail to inform decision-making at the level of economic sectors and specific industries. While the information provides important headline indicators, it is often not specific enough to guide sectoral policies in the domains of primary industries, cities and trade. A first step of sectoral disaggregation into production and consumption was introduced through the adoption of the material footprint indicator. More analysis is required, however, to establish material input information for at least broad economic sectors to move towards a true satellite account for material flows. Such analysis could be used in informing sectoral policies and to monitor progress of such policy initiatives. This is important to strengthen the value of the information provided beyond the policy community by increasing its usefulness for business decision-making.

Linking pressures, impacts and global limits

The data sets and indicators presented by the IRP are pressure indicators for material flows. The pressures have been linked to the main drivers of material demand – population, consumption and economic growth. These indicators allow for early diagnosis of economic and environmental issues and can be used to guide policy intervention. Pressures are related to environmental impacts through well-known processes and pathways. These environmental impacts include diverse issues such as climate change, resource depletion, waste and pollution, toxicity and human health. In many cases it is possible to establish global limits for environmental pressures and impacts such as, for example, the amount of additional greenhouse gas emissions that would keep the global climate below two degrees of warming. More research is needed, however, to increase the knowledge base around these important linkages and explore how they play out in different regional settings.

Policy support

Data sets and indicators are used by the policy community at different stages of the policy cycle. They help in identifying issues, establishing objectives, goals and targets, and monitoring progress of policy initiatives. There will need to be a greater focus on the information needs of the policy and business communities to tailor the data and information to specific policy domains to better assist the formulation of regional, national and sectoral policy frameworks, to identify policy tools and measures and to improve the monitoring capacity of regions and nations. Aligning the knowledge base to the technical assistance to countries provided by different United Nations agencies, especially in the context of monitoring the SDGs and with a strong regional focus, will support a process by which well-designed policies can guide global sustainable development.

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Growing concern about assuring affordable, equitable and environmentally sustainable access to natural resources is well founded. Global use of natural resources has accelerated during the past decade and emissions and waste have grown in line with growing extraction of natural resources. Monitoring natural resource use and decoupling economic growth from natural resource use will be instrumental in meeting the United Nations Sustainable Development Goals. In this new report we show global natural resource use trends over four decades and propose indicators for evidence-based policy formulation.

The data and indicators presented address resource requirements of production and consumption for the globe, for seven world regions and for every country. The indicators are good proxies for global environmental impact and material standard of living. They vary immensely between countries and regions and show vast challenges and opportunities ahead as we transition to a prosperous, equitable and environmentally-friendly global society.

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