Chapter 4. The material basis of the global economy

This chapter examines global trends in material flows and resource productivity using tools from Material Flow Analysis (MFA) and data from Material Flow Accounting (see the Reader's Guide for data sources). In MFA, the term "materials" is often used in a broad sense, so as to encompass all material-related flows arising at all stages of the material cycle. It refers to both materials and products derived from natural resources that are used as inputs into human activities, as well as residuals (such as waste or pollutant emissions) arising from their extraction and use, and ecosystem inputs (such as nutrients, carbon dioxide, and oxygen) required for their extraction and use. Here the focus is on "material resources" that designate the usable materials or substances (raw materials, energy) produced from natural resources. These usable "materials" include energy carriers (gas, oil, coal), metal ores and metals, construction minerals and other minerals, soil and biomass. Ecosystem inputs and pollutant outputs are not considered.

MATERIAL EXTRACTION RATES

Domestic extraction used (DEU) measures the flow of materials that originate from the environment and physically enter the economy to be transformed into or incorporated in products. These materials are usually of economic value.

Domestic material consumption (DMC) provides a measure of the amount of materials directly consumed by economic activities within an economic system (e.g. a country). DMC equals DEU plus imports minus exports. *At the global level DEU and DMC are equivalent*.

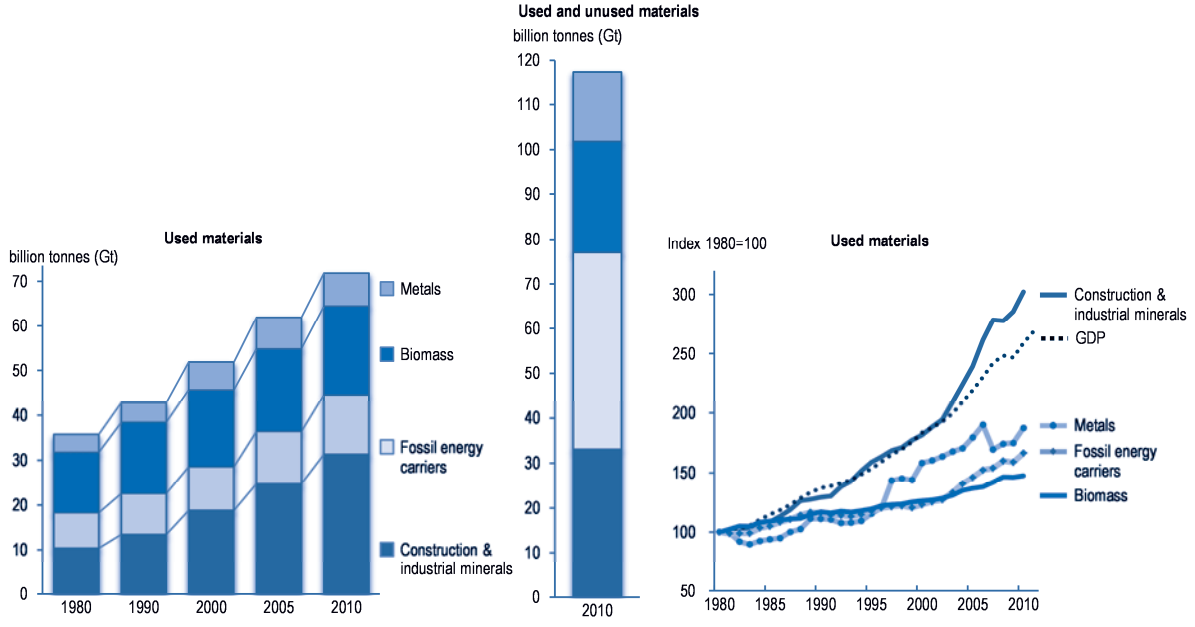
See Glossary.

Global extraction of material resources continues to grow

The amount of materials extracted, harvested and consumed worldwide reached nearly 72 billion metric tonnes (Gt) per year in 2010. This is twice as much as in 1980 when global material extraction was around 36 Gt, and an estimated ten-fold increase since the early 1900s when extraction was estimated at around 7 Gt (SERI/WU material flows database; Krausman *et al.*, 2009). Based on these global figures, OECD countries accounted for 27% of domestic extraction of used materials (DEU) worldwide in 2010 (compared to 46% in 1980), while the BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa) accounted for 51% (compared to 30% in 1980).[1] Although more updated global figures are not currently available, given the limited growth of the global economy since the 2008 financial crisis, material use likely stays at around 72-75 Gt today.

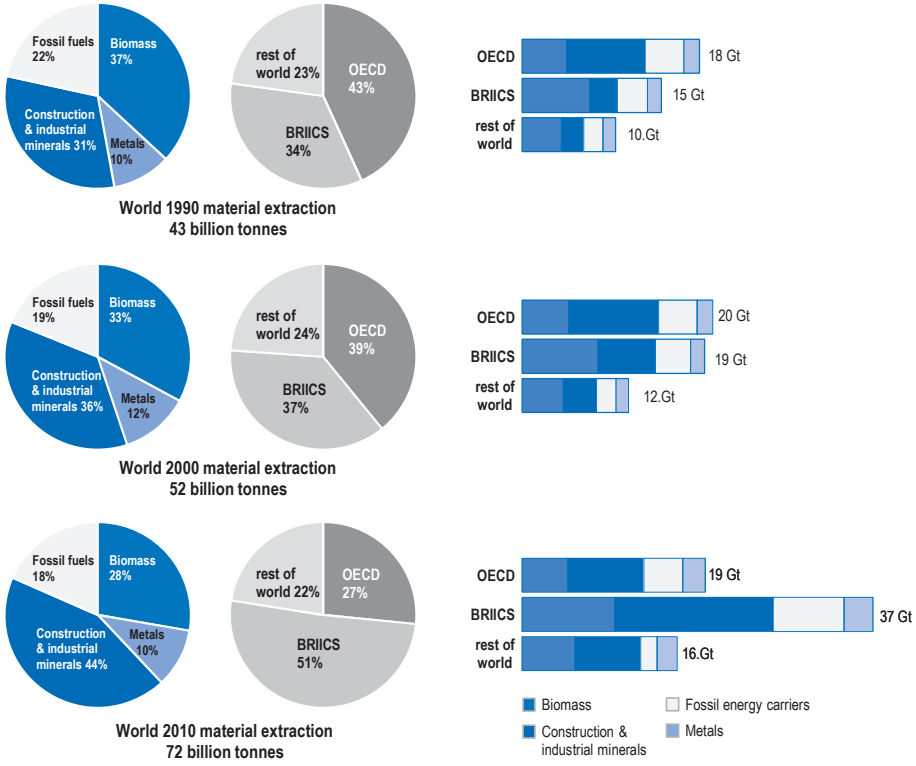
Material use is expected to continue growing, in line with economic activity, with one projection expecting it to reach 100 Gt by 2030.[2]

Figure 4.1. Global material resource extraction, trends and materials mix, 1980-2010



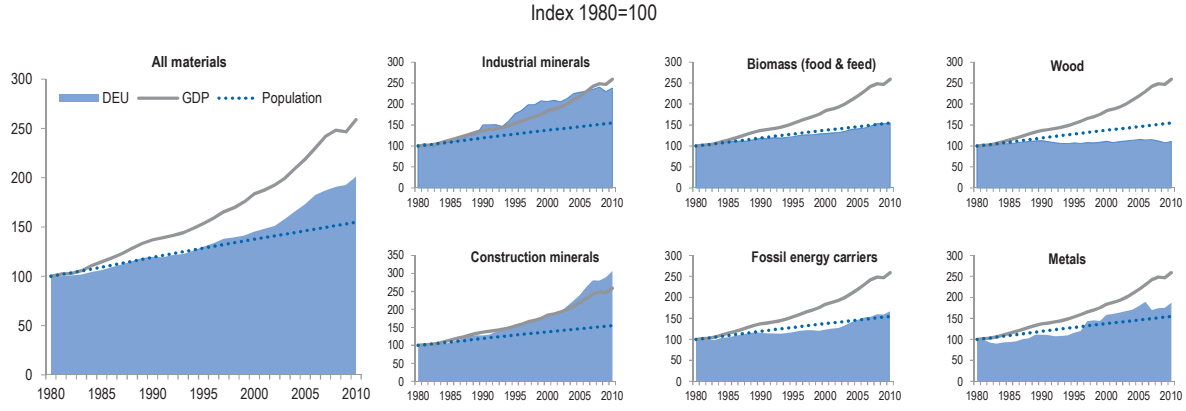
Source: SERI/WU (2014) material flows database, *www.materialflows.net*.

Figure 4.2. Global material resource extraction, geographical distribution and materials mix, 1990-2010



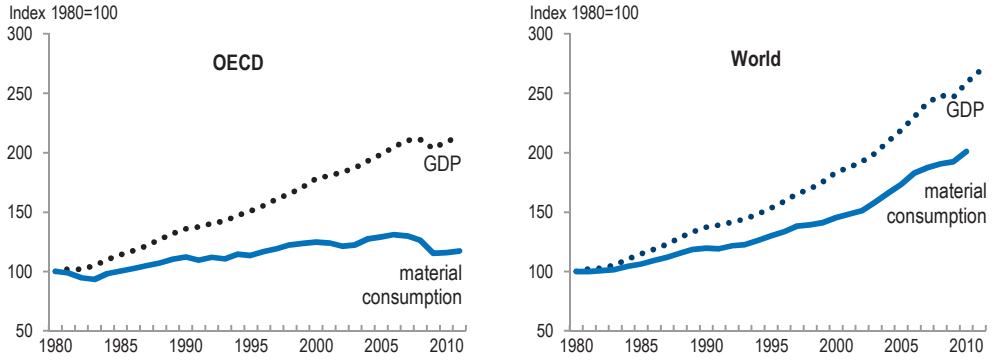
Source: SERI/WU (2014) material flows database, *www.materialflows.net*

Figure 4.3. Global material extraction, population and GDP, by material group, 1980-2010



Note: GDP in USD at 2005 prices and PPPs. Material extraction: used materials only
Source: SERI/WU (2014) material flows database, *www.materialflows.net*

Figure 4.4. Decoupling trends, OECD and world, 1980-2010



Source: SERI/WU (2014) material flows database. *www.materialflows.net*

Growth has been uneven across materials and over time

Growth has been primarily driven by increased global demand for construction minerals, biomass for food and feed, fossil energy carriers. These three material groups account for 80% of total global material extraction.

Over last century extraction of resources from non-renewable stocks has grown while extraction from renewable stocks has declined, reflecting the shift in the base of the global economy from agriculture to industry. Once accounting for an estimated 75% of global material extraction, biomass accounts for less than a third of total extraction today (Krausman *et al.*, 2009; SERI/WU material flows database). Non-renewable resource extraction now represents over two-thirds of global material extraction with construction minerals making up 42% of global DEU in 2010 (compared to 34% in 2000), fossil energy carriers 18%, and metal and metal ores 10%. Industrial minerals account for around 2% of global extraction.

Although global material use has been increasing steadily overall, growth has varied across material groups, pointing to differences in the way economic and demographic factors are driving their evolution.

Metals

Over the last 30 years, growth in raw material demand (in relative terms) has been strong for **metal ores**, reflecting the importance of economic growth as a demand driver. Global metal extraction rose from 3.9 to 7.4 Gt or by 87% between 1980 and 2010. But growth has not followed a steady upward trajectory; after declining in the early 1990s, the rate of metal extraction witnessed a significant upswing beginning in the late 1990s and the early 2000s. This acceleration was due to the high demand from economies entering their energy- and material-intensive development phase, coupled with the ongoing high levels of consumption in developed economies.

Construction minerals

The strongest growth has been in demand for **construction minerals**. It has expanded rapidly, growing by 20Gt, a threefold increase between 1980 and 2010. As with metal ores, global extraction of construction minerals began to accelerate in the early 2000s; it grew on par with global economic growth till the early 2000s, and much faster since.[3] Economic growth and the associated expansion of the construction sector (building industries, commercial facilities and transportation and other infrastructure) have a strong influence on demand. But the need for construction

minerals is related to both changes in demographics (e.g. the amount and type of housing needed) and in average wealth (e.g. the size of dwellings), as well as a number of country specific factors (i.e. geography, urban planning, consumer preferences). In recent years, these economic factors appear to have become the driving force.

Fossil energy carriers

Global extraction of **fossil energy carriers** expanded less than metal ores and construction minerals – growing by 4.8 Gt or 66% between 1980 and 2010. Throughout the 1990s when real crude oil prices were relatively low, the extraction of fossil energy carriers stabilised and in some years even declined. But by the early 2000s, as in the case of metal ores and construction minerals, extraction began to trend upward again driven by an expanding global economy.

Biomass for food and feed

From 1980 to 2010, both the world's population and the extraction of agricultural biomass increased by about 55%. Because food is essential to sustain human life, it is not surprising that changes in the amount of **biomass for food and feed** harvested are closely related to changes in population. But income also influences demand, although generally to a lesser extent. Changes in wealth typically bring changes in dietary habits, including both in the types of foods eaten and the total food intake. Meat consumption, in particular, tends to increase with wealth. More biomass (in terms of feed) is required to support a meat-based diet relative to a vegetarian diet.

Wood

Wood harvesting experienced the slowest rate of growth. The harvesting of wood grew by 11% between 1980 and 2010, significantly lower than population growth. Increased paper recycling and competition from digital media have likely contributed to flat demand for wood fibre.

Industrial minerals

Growth in the extraction of industrial minerals is more volatile than other material groups. This group consists of variety of minerals ranging from phosphate rock to diamonds, and demand is likely driven by the interaction of a number of factors. Trend data must be interpreted with caution since there are many uncertainties associated with the underlying estimates.

Material extraction increases by two-thirds when unused materials are considered

Along with 72 Gt of material resources that were extracted and entered the global economy in 2010, an additional 45 Gt of materials were extracted as a consequence, but **not used in the production process**. These materials – referred to as unused domestic extraction (UDE) – include mining overburden, harvest residues and fisheries by-catch. Soil erosion from agriculture is another important unused flow, but is not considered in this report.[4] They generally have low or no economic value. Although these materials are unused from the perspective of direct consumption and production, they often end up having other uses. Mining overburden is stored for later use in land reclamation, as is waste rock, which can also be used in road construction. Harvest residues can be used as biofuels. Fisheries by-catch can be sold as food or processed into feedstock or organic fertilizer.

Unused extraction is important, particularly for some materials; it accounts for almost 70% of the total extraction associated with **fossil energy carriers** (due to the large volume of unused materials associated with coal extraction) and more than half for **metals**, but much less for biomass and construction minerals. With unused extraction taken into account, fossil energy

carriers overtake both biomass and construction minerals as the dominant material resource extracted globally, accounting for almost 40% of extraction in 2010.

Unused domestic extraction has grown almost on a par with domestic used extraction. Increased coal production, particularly in Australia, China, India and Indonesia from 2002 onwards, likely was a factor behind this growth in the amount of unused material extracted globally, as is increased metal ore extraction.

DECOUPLING AND MATERIAL PRODUCTIVITY

What is resource productivity? Resource productivity refers to the effectiveness with which an economy uses materials extracted from natural resources (physical inputs) to generate economic value (monetary outputs).

Decoupling is breaking the link between "environmental bads" and "economic goods". Absolute decoupling occurs when environmental degradation is decreasing while the economy is expanding. Decoupling is relative when environmental degradation is growing, but at a slower rate than the economy. In practice, the **measurement** of decoupling refers to the relative growth rates of a direct pressure on the environment and of an economically relevant variable to which it is causally linked.

See Glossary.

There are signs of a relative decoupling in material use from global economic growth

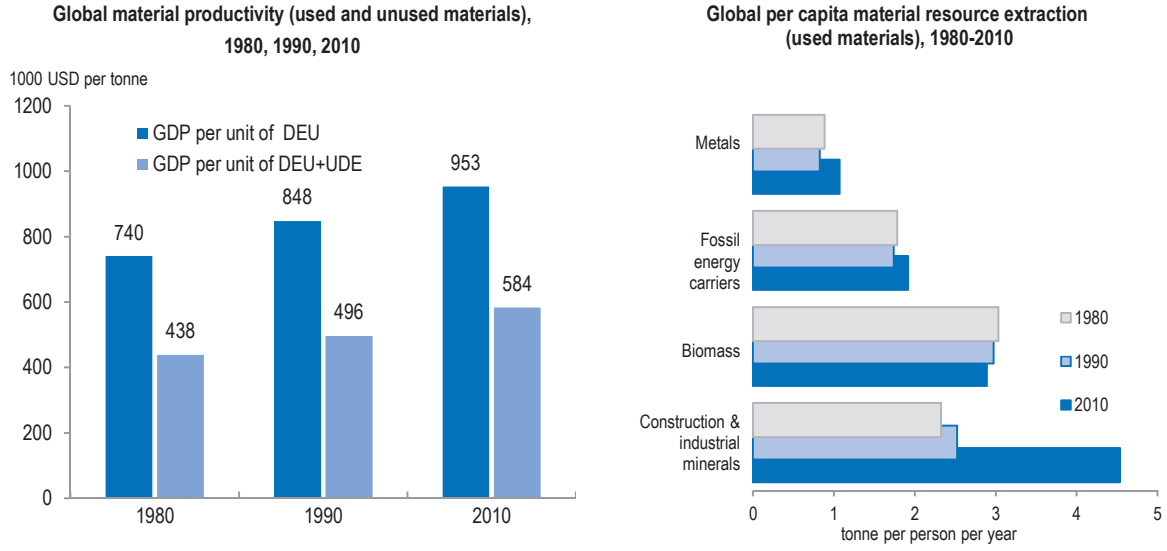
Global material use continues to grow in absolute terms, but progress is being made in decoupling material extraction and consumption from economic growth. Between 1980 and 2010 the material productivity of the global economy improved by amost 30%, rising from $0.70 per kilogram (2005 USD and PPPs) in 1980 to $1/kg by 2010 – meaning that the global economy generated 30% more economic value with a kilogram of material resources in 2010 than in 1980.

Productivity levels are reduced once **unused materials** are taken into account. With unused materials, in 2010 each kilogram of material resource generated $0.6 compared to $0.4/kg in 1980, a productivity loss of 40%.

But material use per capita remains high

The average person is using more material resources today than thirty years ago. Throughout the 1980s and the early 1990s per capita DMC (DEU) remained fairly stable around 8 tonnes (t) per person per year, but has been rising over the last fifteen years. In 2010 per capita DMC reached over 10 t per year, meaning that on average each person is using 29 kg of material resources per day, including 12 kg of construction minerals, 7 kg of biomass for food and feed, 5.3 kg of fossil energy carriers and 3 kg of metals. If unused domestic extraction (UDE) is included, per capita material use rises to nearly 17 tonnes per person per year in 2010 (46.6 kg per person per day), up from 13.6 tonnes in 1980.

Figure 4.5. Global material productivity and intensity per capita, 1980-2010



Notes: GDP in 2005 USD and PPPs.

Source: SERI/WU material flows database (*www.materialflows.net*), OECD (2013), OECD (2013), "Material resources", *OECD Environment Statistics* (database)

ENDNOTES

1 The OECD material flows database includes information on all 34 OECD member countries and BRIICS countries, but does not include world totals. The material flows database by the Sustainable Europe Research Institute (SERI) and the Vienna University (available at *www.materialflows.net*) has data on domestic extraction used (DEU) and unused domestic extraction (UDE) for 188 countries from which world totals were estimated. For consistency, OECD and BRIICS countries' global shares were calculated based on SERI/WU data rather than data from the OECD material flows dataset.

2 Projection by Wuppertal Institute based on business as usual scenario.

3 In the case of construction minerals, information sources have estimated missing data from non-missing values and trends in GDP (e.g. in SERI, 2010). As a result, correlations between the supply or demand of construction minerals and macroeconomic data as GDP must be interpreted with caution (Dittrich, 2010).

4 SERI has estimated that global soil erosion from agricultural land ranges between 25-50 billion tonnes a year. The indicator UDE in the OECD material flow database does not account for soil erosion. Estimating soil erosion is complex and beyond the scope of this report.

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