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The Material Basis of the Global Economy

Implications for Sustainable Resource Use Policies in North and South

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Abstract

Over the past 15 years, material flow accounting and analysis (MFA) has been established as an influential framework for policy-oriented assessments of anthropogenic use of natural resources. So far, however, no reference data for overall scale and trends of global extraction of natural resources and their distribution between different world regions has been available. In the course of an ongoing EU project entitled "Modelling opportunities and limits for restructuring Europe towards sustainability (MOSUS)", total (used and unused) material extraction has been assessed for all countries of the world.

This paper presents a comprehensive quantification of the material basis of the global economy, i.e. used domestic extraction aggregated on the global level, in a time series from 1980 to 2002. We analyse time trends for major material groups (fossil fuels, metals, industrial and construction minerals, and biomass) disaggregated into seven world regions. This allows for (a) an illustration of the global economy's physical growth driven by world-wide processes of economic integration over the past 25 years, and (b) an indication of the world-wide distribution of environmental pressures associated with material extraction. Furthermore, we link physical extraction data with socio-economic indicators such as GDP and population allowing for an assessment of different patterns of resource productivities and inequalities in per capita resource extraction between industrialised and developing economies. The paper concludes with policy recommendations for the international agenda, and for industrial as well as for developing countries intended to decrease levels of natural resource use in the north and to decrease the dependence of developing countries on exports of primary commodities.

Keywords: material flow accounting and analysis, global resource use, sustainable development indicators, environmental policy, international trade

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1. Introduction

In the past 20 years, several methods have been developed which enable quantifying the use of natural resources by modern societies. Material Flow Accounting and Analysis (MFA) is one of the key methods and internationally recognised as an important tool for evaluating environmental policies. The principle concept underlying MFA is a simple model of the interrelation between the economy and the environment, in which the economy is an embedded subsystem of the environment. Similar to living beings, this subsystem is dependent on a constant throughput of materials and energy. Raw materials, water and air are extracted from the natural system as inputs, transformed into products and finally re-transferred to the natural system as outputs (waste and emissions). To highlight the similarity to natural metabolic processes, the terms "industrial" (Ayres, 1989) or "societal" (Fischer-Kowalski, 1998) metabolism have been introduced.

According to the first law of thermodynamics (the law of the conservation of mass), total inputs must by definition equal total outputs plus net accumulation of materials in the system. This material balance principle holds true for the economy as a whole as well as for any sub-system (an economic sector, a company, a household). It thus follows that increasing problems associated with waste generation and emissions are directly related to the scale of material input. From this point of view, a reduction in the use of materials (i.e. dematerialisation) by means of increasing resource efficiency could provide a successful strategy to combat global environmental problems such as climate change, the loss of biodiversity or desertification.

A comprehensive assessment of global resource extraction has recently been performed in the course of an ongoing EU research project entitled *MOSUS* ("Modelling opportunities and limits for restructuring Europe towards sustainability", see www.mosus.net for more information). Resource extraction data, disaggregated by more than 200 material categories, has been compiled for 188 countries in a time series from 1980-2002. The compilation of material input data followed the nomenclature and categorisation of materials listed in the handbook for economy-wide material flow accounting published by the Statistical Office of the European Union (EUROSTAT, 2001) and covers the following material groups. The number of material categories within each group is given in brackets.

- Fossil fuels (6)
- Metal ores (37)
- Industrial minerals (41)
- Construction minerals (9)
- Industrial and construction minerals (15)
- Agriculture (139)
- By-products of agriculture (3)
- Grazing (1)
- Forestry (2)
- Fisheries (3)
- Other biomass (4)

For the purpose of presenting the data in this paper, material categories have been aggregated into four main groups: fossil fuels, metals, industrial and construction minerals, and biomass.

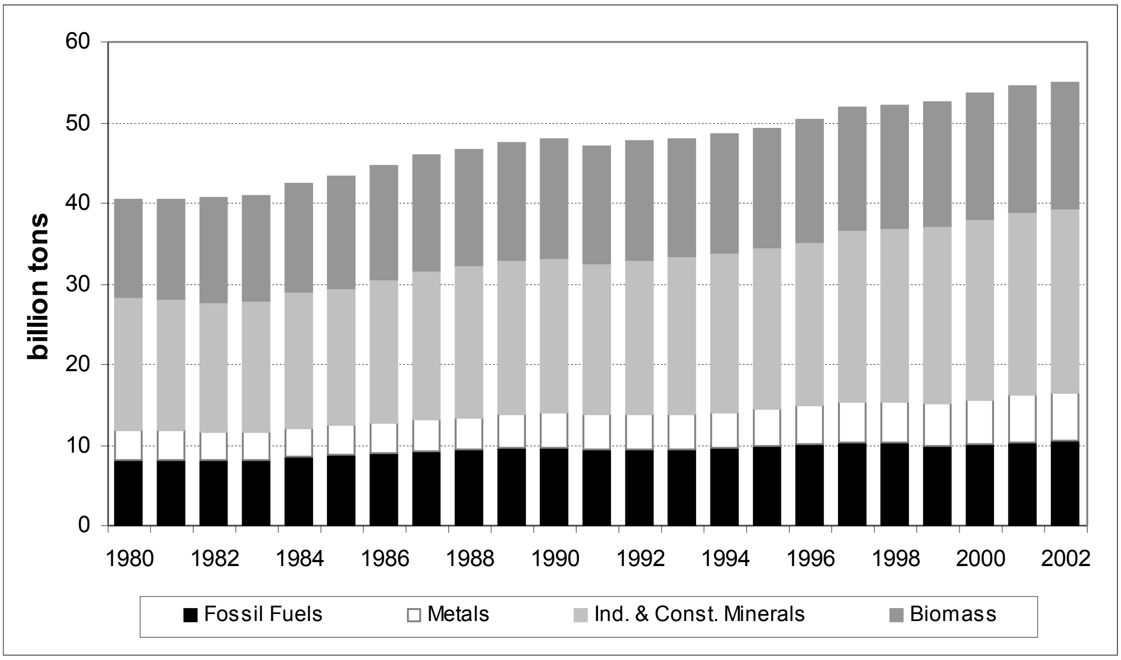
The international database on natural resource extraction is mostly based on international statistics, such as the online database of the Food and Agricultural

Organisation of the United Nations (FAO), UN Industrial Commodity Statistics, US Geological Survey and the World Mining data set. As coverage of construction minerals in official statistics is still unsatisfactory, in particular in non-OECD countries, an estimation procedure based on GDP/capita levels and trends in population growth was applied for all countries, resulting in numbers for per capita extraction of construction minerals, which – according to interviewed experts and information from geological institutes – can be assumed to be realistic for different world regions.

2. Results

Figure 1 presents the overall material basis of the global economy (including only used materials) between 1980 and 2002.

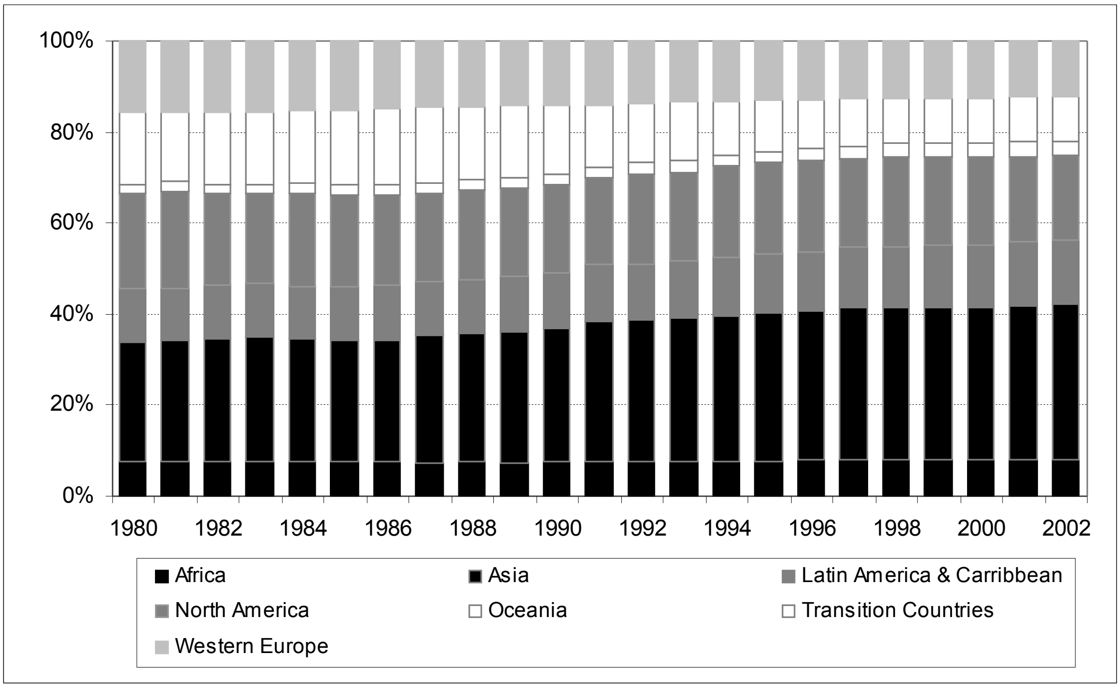
Figure 1: Global resource extraction by material category (in billion tons)



This figure illustrates that global resource extraction grew more or less steadily over the past two decades, from 40 billion tons in 1980 to 55 billion tons in 2002, representing an aggregated growth rate of almost 36%. However, growth rates are unevenly distributed among the main material categories. Particularly the extraction of metals increased disproportionately, indicating the continued importance of this resource category for industrial development. Increases in biomass extraction were below average. The share of renewable resources thus decreased on the global level.

In Figure 2, global resource extraction data is disaggregated by world regions illustrating the shares of each region in total extraction. The region "Transition Countries" aggregates Eastern European and ex-USSR countries.

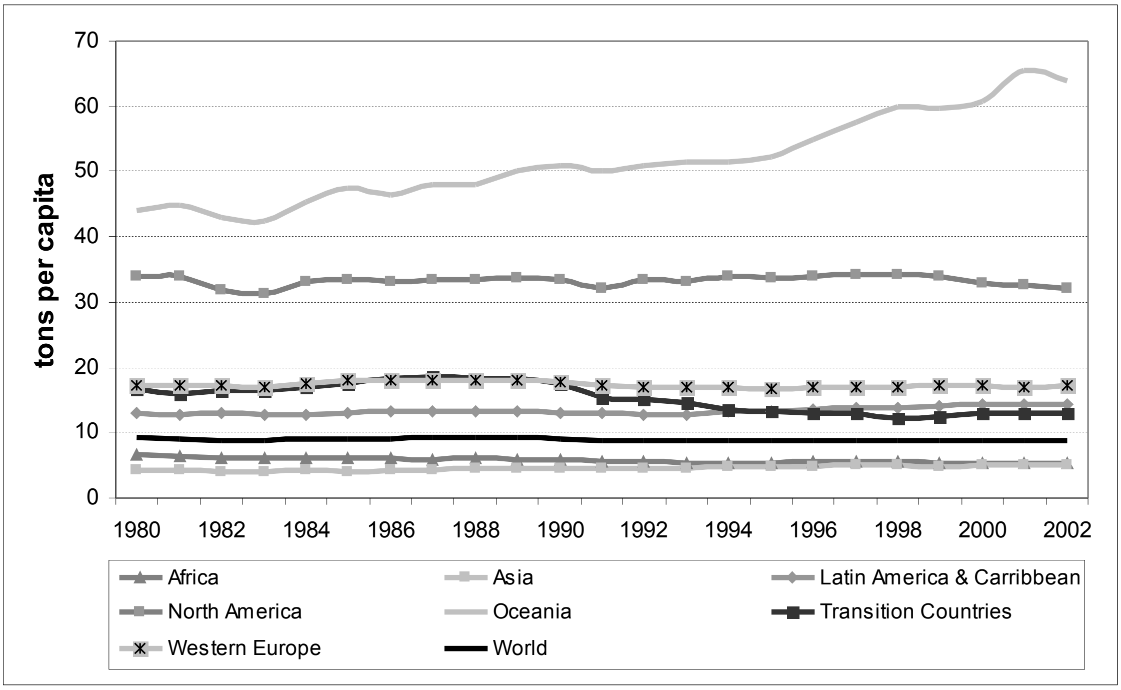
Figure 2: Shares of global resource extraction by world region (in billion tons)



The regional analysis shows that Asia's share in global resource extraction has increased considerably as a consequence of rapid industrialisation in countries such as China and India. In China, for example, extraction of fossil fuels, metal ores and biomass grew by 130%, 160% and 80%, respectively, between 1980 and 2002. The total increase in used extraction was 123%, as compared to an increase of 70% in India. Other than in Asia, a considerable part of the Latin American increase in domestic resource extraction results from specialisation in resource-intensive export products, such as metal ores (see also Muradian and Martinez-Alier, 2001). The regional used extraction of metal ores thus increased by 161%. The most dramatic decline is observed for the transition countries, which faced deep economic recession in the beginning of the 1990s (for example, real GDP of the Russian Federation fell by 30% between 1992 and 1998), resulting in a reduction of domestic resource extraction of -15%. The share of Western Europe declined, mainly reflecting a reduction of metal ores and fossils extraction. These raw materials are increasingly being substituted by imports from other world regions (see Schütz et al., 2004).

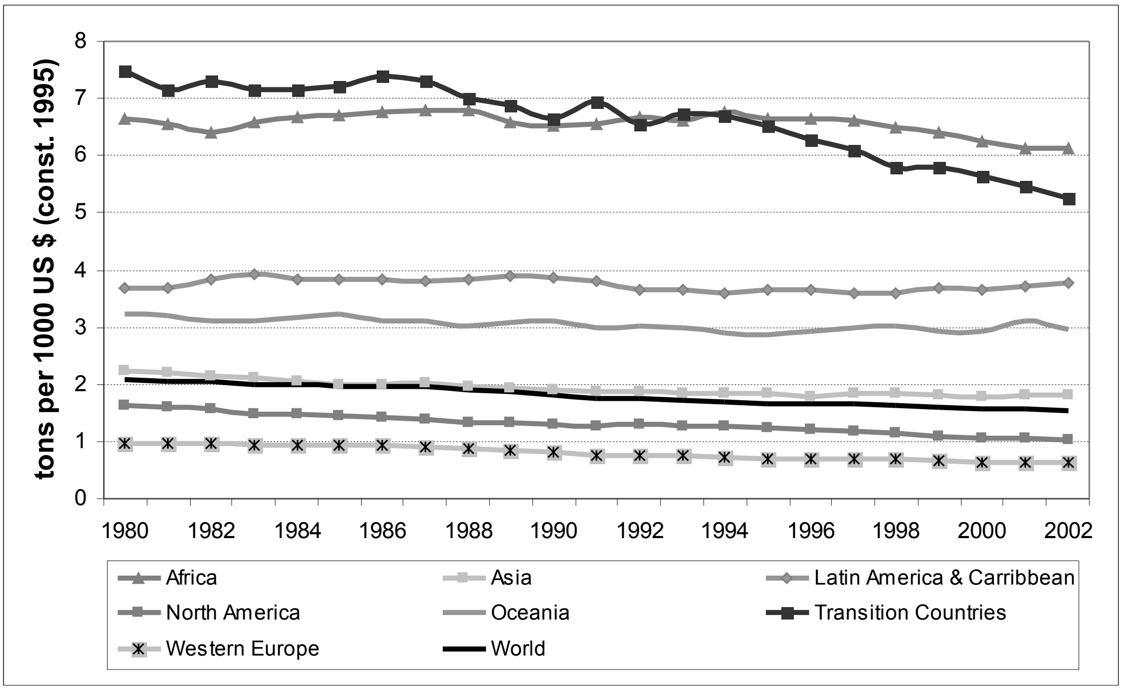
Figure 3 shows numbers for global resource extraction per capita in the eight world regions and as a global average. The highest numbers for per capita resource extraction are observed for Oceania with 64 tons per capita at the beginning of this decade. This reflects the steep increase in production of fossil fuels (in particular coal) and metal ores in Australia over the past 25 years, which grew by 192% and almost 200%, respectively. North Americans rank second with a per capita extraction of just over 32 tons, due to high amounts of industrial minerals, fossil fuel and biomass extraction. The economic decline in the transition countries is again evident in this figure, with per capita extraction dropping from levels of about 18 tons in the 1980s to about 13 tons at the end of the 1990s. With 5-6 tons, developing regions in Africa and Asia are characterised by the smallest per capita numbers. World average per capita extraction slightly dropped from 9.2 tons in 1980s to 8.8 tons in the 1990s.

Figure 3: Global resource extraction per capita by world region (in tons per capita)



In figure 4, the material intensity, calculated as the relation of domestic material extraction to constant GDP, is shown for the different world regions. This indicator expresses the amount of economic output generated per unit of natural resource extraction.

Figure 4: Material intensity by world region (in tons per constant 1000 US $)



Compared to the per capita perspective, a reverse picture is observed. Industrialised economies are characterised by the lowest material intensities (or highest eco-efficiency), with Western Europe being world-leader with around 1 ton per 1000 US $ GDP in the 1980s and improving to 0.6 tons at the beginning of this decade. Although North America has high levels of per capita resource extraction, material intensity is still low and declining. The two major drivers for this trend in industrialised regions are the use of new technologies with improved material and energy performance and structural change of economies towards service sectors characterised by less material input per economic output. Together with a significant improvement of eco-efficiency in Asia (resulting in a downward trend of the material intensity curve), these two regions also determined the development of eco-efficiency on the global level, which increased from 2.1 tons in 1980 to 1.6 tons in 2002. This means that about 25% less material inputs were needed to produce one unit of constant GDP at the end of the time period as compared to the year 1980. Hence, relative de-coupling of economic growth from the extraction of natural resources was achieved on the global level. The above figure also reveals the enormous differences concerning the material intensity when comparing rich industrialised regions (except Oceania with its special characteristics, see above) to developing regions. Although the situation improved significantly in the region of Accession Countries in the past 10 years, particularly in Eastern European countries, the generation of GDP is still linked to a domestic resource extraction almost 4 times higher than world average.

We emphasise that the data presented above only includes domestic extraction of natural resources and does not take into account trade aspects. We can therefore draw robust conclusions with regard to the aggregated global level. However, for specific world regions, the numbers for per capita resource consumption and for material intensity of an economy can significantly change when international trade flows are considered (which means that adding imports to and subtracting exports from the national material flow accounts) (Giljum/Eisenmenger, 2004). Per capita numbers and material intensities will likely increase in regions with high amounts of physical imports (such as Western Europe and Japan), while decreasing for regions with high levels of resource-intensive exports (such as oil or metal producing countries) (e.g. Schütz et al., 2004).

3. Policy Implications

The results presented in this paper hold important implications for the formulation of policy strategies towards a more sustainable use of natural resources in both industrialised regions such as Europe and countries acting as resource suppliers mainly located in the global South. In many industrialised (and newly industrialised) countries, relative de-coupling of domestic material extraction from GDP growth has been observed. In some developing countries, on the other hand, domestic resource extraction grows even faster than economic performance, owing to the fact that a substantial share of material extraction is linked to export activities. This highlights the importance of including trade aspects in international environmental policy. While Europe will need to implement policy measures to further reduce overall primary material extraction (both domestic and abroad) in order to achieve more sustainable production and consumption patterns, policies in developing countries need to focus on vertical and horizontal diversification of economic structures in order to reduce their dependence on primary commodity exports. What follows is a brief summary of the main strategies for different parts of the world.

Under the goal presented above, especially the Northern countries are challenged to drastically reduce their use of natural resources. Recent studies (e.g. Fischer et al., 2004) revealed that there exist high potentials for economically profitable resource savings even under current policy regulations and at prevailing price levels. The internalisation of environmental costs and the implementation of further fiscal and administrative policy measures fostering dematerialisation would lead to a price increase of natural resources in the consumer countries and thus would stimulate technological change towards higher eco-efficiency. Such measures, usually referred to as economic ones, include, among others, ecological fiscal reforms (e.g. material input and energy taxes), reforms of the subsidy systems (e.g. temporary support for development of new eco-efficient technologies and materials), certificates trading systems, and eco-efficient public procurement (Behrens, 2004). Along with a tax relieve on labour this could help lifting the reduction of material and energy costs (instead of reducing labour costs) to a priority area of action of public and private decision makers in the North. Focussing on key sectors that are either directly (e.g. mining, agriculture, fisheries) or indirectly responsible for large amounts of natural resource extraction (e.g. energy and transport, industry) will benefit the efficiency of the selected mix of instruments.

As stated above, the cruical goal for the South will be to reduce dependence on primary commodity exports. This can be achieved by increasing efforts to diversify economic structures – a strategy that has been of vital importance for development in the North. Similarly, encouraging processing of natural resources domestically ("vertical diversification") is expected to increase the added value of exports and reduce the negative impacts of price fluctuations on world markets for primary commodities (Bocoum-Kaberuka, 1999). This would enable Southern economies to reduce extraction rates of natural resources and thus decrease pressures on the domestic environment. Simultaneously, "horizontal diversification" should be enforced, in order to build up other, less resource-intensive sectors. Active investment in education and training to foster the acquisition of skills in the labour force is one central measure to shift comparative advantages away from unprocessed to processed primary production and later on from primary production to manufacturing, which on average is more skill-intensive than activities in the primary sectors (Wood, 1999). Supporting structural change would also be a proactive strategy to avoid economic crises related to highly unstable commodity prices.

Other measures in the South may include an environmental fiscal reform (EFR) for poverty reduction, as advocated by the DAC Network on Environment and Development Co-Operation of the OECD (OECD, 2004). An EFR of that kind may be helpful in addressing environmental problems associated with extraction activities that impact the poor. Including extraction levies and material input taxes, an EFR can also help indirectly, by generating or freeing up resources for investment in infrastructure critical for the poor, such as water supply and sanitation. Similarly, freed-up budget resources can be used for other kinds of pro-poor investments such as health and education. An EFR for poverty reduction may thus play a potentially important role in achieving the Millennium Development Goals, while benefiting the environment.

Regarding the international agenda, sustainability goals will not be achievable without considerable North to South transfer of financial and technological resources. Debt is a considerable driver of resource extraction in developing countries, the returns of which are used to meet debt obligations. A redistribution of financial resources in form of debt relief or co-financing of development projects will thus take pressure from natural resources in the South. Additionally, increasing transfers of environmental technology and know-how will help to improve resource efficiency and reduce waste and emissions of production processes in the South.

Potential environmental benefits can also be expected from the provision of increasing market access for Southern products in the North by eliminating tariff distortions, reforming the subsidy system etc. Since these barriers exist not only for agricultural products but also for manufactured ones, an alleviation of these barriers will increase incentives to manufacture products in the South instead of merely exporting the raw materials. Northern environmental standards will apply to these products and may have spill-over effects on the environmental quality of products sold in the South. Furthermore, increasing income through extended market access is expected to have environmentally beneficial effects on the structure of developing economies, leading to an accelerated shift towards the less resource intensive service sector.

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