german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

EQuIP

Enhancing the Quality of Industrial Policies

TOOL 6

Greening Industry – Module 2: Material Efficiency

EQuIP Tool 6: Greening Industry

Module 2: Material Efficiency

Summary Sheet

Enhancing the Quality of Industrial Policies (EQuIP) – Tool 6.2	
Name of the tool:	Greening Industry/ Module 2: Material efficiency
Objective:	The material efficiency-related part of Tool 6 provides a set of indicators and related analyses, which (a) provide information on the economy-wide performance in terms of material use and efficiency; (b) reflect on countries' material self-sufficiency and the implications for the material security of the manufacturing sector; and (c) evaluate the importance of the manufacturing sector in overall material use of the economy as well as the material use of manufacturing sub-sectors.
Key questions addressed:	How has the absolute material use of the national economy developed over time? How has the material efficiency of a country developed over time and how can its performance be evaluated compared to other countries? How self-sufficient is an economy with regard to raw materials, i.e. how dependent is the overall economic system on raw materials imported from abroad? What is the share of the manufacturing sector in the overall material demand of the domestic economy? Which are the manufacturing sub-sectors with the highest material use in a country? How do the various manufacturing sub-sectors differ with regard to their demand for certain raw materials? Which manufacturing sub-sectors are characterised by high value added, while having relative less material use compared to other sub-sectors, and thus should receive special attention in a greening industry strategy?
Indicators used:	Domestic material consumption (DMC) on the economy-wide level Material efficiency of the economy (GDP/DMC) Self-sufficiency of the economy (by main material groups) Material use of the manufacturing sector (as share of material use of all sectors) Material use of manufacturing sub-sectors (by main material groups)

Contents

1. Introduction

1.1. Objectives of the Greening Industry tool

This tool helps to understand and evaluate how efficiently a country and in particular its manufacturing industries use natural resources in their production activities. This is of particular relevance, as increasing resource efficiency – as well as increasing recycling rates – is understood as an essential means when aiming at greening an industrial system. Improving industrial performance in this regard is closely related to the creation and boost of “green industries”. Green industries provide environmental technologies, goods and services – i.e. products aimed at reducing negative environmental impacts – and as such are an important driver of the development towards the greening of industry as a whole. When this leads to the creation of new “green jobs”, supporting the creation of such industries can result in triple-win (economic, environmental and social) scenarios.

The Greening Industry tool focuses on inputs of natural resources to manufacturing industries, such as energy and raw materials, and assessments of resource efficiency. Issues related to pollution and waste production, which return to the environment as an output of production activities, are only considered in this tool to a limited extent, although these categories are of high importance for the environmental performance of industries.

The focus is set on natural resource inputs, because the positive economic and employment impacts of the greening of industries are generated through using natural resources more efficiently on the input side. This efficiency improvement lowers the costs of production and thus entails positive consequences for industrial growth and competitiveness, as many existing examples from industrialised countries have illustrated (see, for example, the various case studies in EIO, 2011). At the same time, material efficiency is a key strategy to de-couple economic growth and industrial development from natural resource use, thus lowering the environmental pressures related to manufacturing activities.

1.2. Importance of material efficiency for the greening industry agenda

Increasing material efficiency in the manufacturing industries can bring about several key advantages, both in environmental and economic terms:

Material efficiency helps de-coupling industrial production from pressures on the natural environment

De-coupling (or de-linking) economic activities from the generation of environmental pressures through the use of various material resources is one core objective of the greening industry agenda. Increasing material efficiency is the key strategy to realise such a de-coupling. In the manufacturing sector, material efficiency can be improved through several strategies: applying resource-efficient technologies, which help save material inputs to production; developing integrated material management systems, which minimise the generation of waste; or specialising in those manufacturing sub-sectors which generate higher value added per unit of material use.

With increasing material efficiency, the overall demand for raw materials is reduced compared to a development path without improvements in material efficiency. Material efficiency thus translates into a relative improvement of the environmental situation, for example regarding the negative environmental impact of resource extraction, or the processing or lowering of emissions produced by manufacturing.

However, material efficiency increases can also lead to so-called rebound effects through lowering production costs and thus stimulating growth and demand. Whether an absolute reduction of environmental pressures can be realised therefore also depends on other factors, such as the implementation of policy instruments (e.g. environmental taxes), which limit these rebound effects.

Material efficiency supports competitiveness

The positive competitiveness impacts of increased energy efficiency have been frequently emphasised, including among others in UNIDO's Industrial Development Report (UNIDO, 2011). The case of material efficiency has only in recent years received more attention and therefore fewer empirical studies are available that investigate the links between material efficiency and competitiveness.

In a survey of more than 550 CEOs and senior management staff from companies in manufacturing industries, executives viewed cost competitiveness of raw material inputs as one of the most important drivers for overall competitiveness in the manufacturing industries, even above competitive wage rates (Deloitte, 2013). Studies on the economy-wide level generally found a positive relation between resource productivity and competitiveness. This can be explained by a number of factors, including the increasing importance of material purchasing costs for manufacturing industries and the positive link between resource productivity and innovation performance (Steger and Bleischwitz, 2009).

In many European countries, increased competition over natural resources on world markets and higher prices of raw materials have provided incentives for several resource-intensive industries, such as cement, iron and steel, chemicals, and paper, to implement resource efficiency measures. Industry representatives generally regard these measures as a key strategy to decrease production costs and thus improve international competitiveness (Ecorys, 2011).

Material efficiency supports diversifying the economy and upgrading export structures

Many developing countries have a rich endowment with raw materials in areas such as coal, oil or metal ores. A key strategy for these countries is to upgrade their industrial structure and diversify their export portfolio, in order to move from simple productive activities in areas such as raw material extraction and processing towards producing and exporting goods with higher technological content and higher value added. EQuIP tools number 3 and 4 focus on the multiple benefits of such a transition, which reduces the vulnerability to external shocks, such as fluctuations in commodity prices (see below), and generates higher welfares for the whole society. Increasing material efficiency can support such a transition from resource-intensive primary production activities towards producing higher value-added goods.

Material efficiency increases material security for industrial production

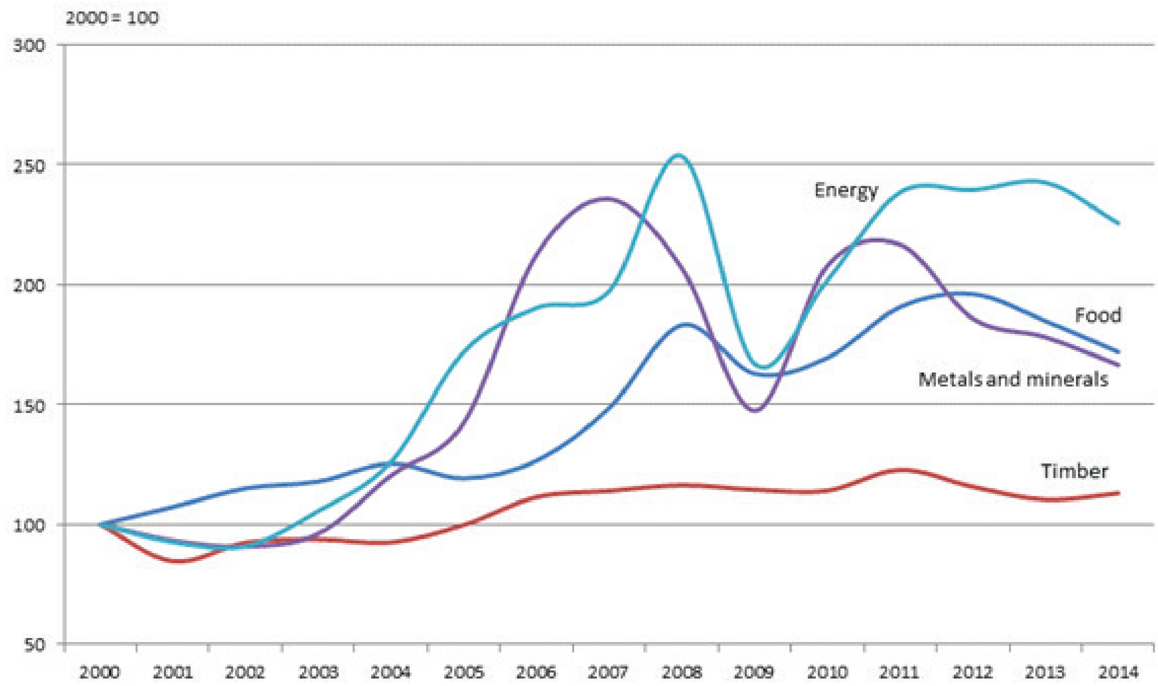
By far not all developing countries have significant production of raw materials within their borders. A large group of developing countries depends on the import of strategic raw materials, such as metal ores, from abroad. For this group, improving material efficiency thus reduces the vulnerability of manufacturing industries, especially when their raw material imports stem from politically unstable countries.

Developing and emerging economies have rapidly increased their absolute material consumption in the past decades and will continue to increase their demand for raw materials, as affluence rises and industrial production expands. In the medium term, increasing material efficiency can thus provide an important contribution to ensuring that the resource base necessary for industrial development will not be depleted for current or future generations. This will also lower the risk of conflicts about access to raw materials.

Material efficiency reduces exposure to economic risks of rising and fluctuating commodity prices

In the past 15 years, commodity prices have generally increased by 50-100% in real terms, according to data from the World Bank (2015), with particular steep increases observed for fossil energy, but also for food and metal ores (see Figure 1). Prices dropped sharply in 2008 and 2009 as a consequence of the economic crisis, but then picked up again quickly. Today, commodity prices generally are at a level far above that at the turn of the Millennium.

Figure 1: Commodity price trends, 2000-2014, year 2000 = 100

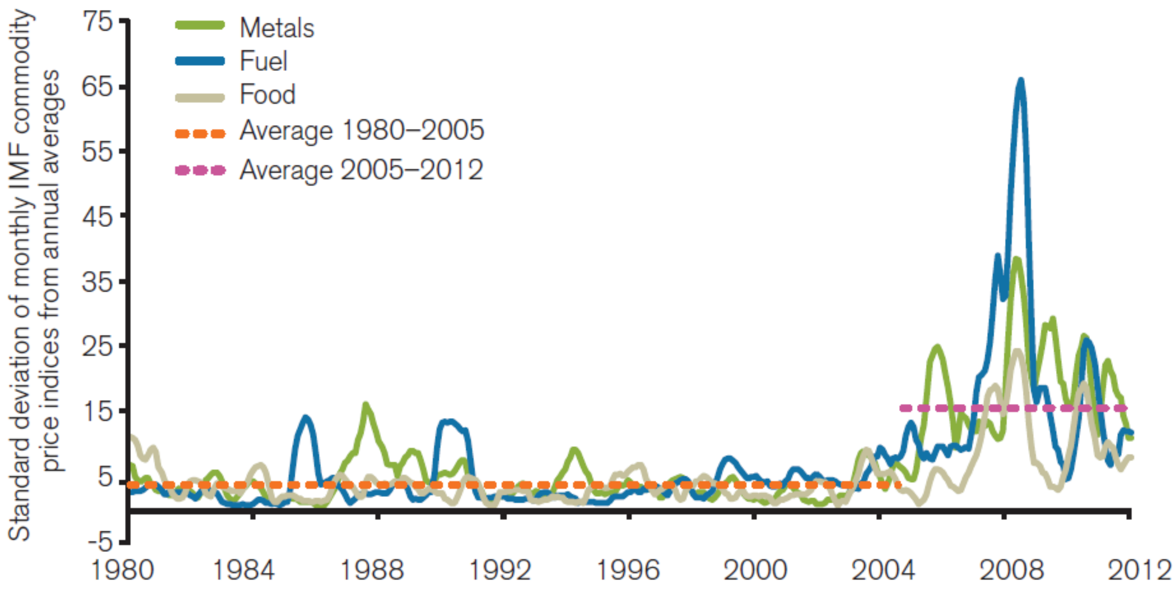


Source: (World Bank, 2015)

For resource-exporting countries, increasing commodity prices generate higher profits from growing export revenues, at least in the short term. However, high commodity prices might also hide medium- to long-term requirements of reducing dependency on a few exports with low value added through more diversified industrialisation. While benefitting commodity exporters, rising prices pose a severe economic problem for those developing countries which rely on commodity imports to maintain their domestic industrial production.

In addition to price increases, raw materials also faced significantly higher price volatility in recent years when compared to past decades. As Figure 2 illustrates, from 2005 to 2012, raw material prices generally were over 3 times more volatile than they were between 1980 and 2005.

Figure 2: Volatility of metal, fuel and food prices, 1980-2005 vs. 2005-2012



Source: (Lee et al., 2012)

High commodity prices in combination with increasing volatility pose a problem to cost planning in manufacturing industries. Material efficiency can help reducing the material costs of production and decreasing the negative effects of high volatility in commodity prices.

Material efficiency can create positive impacts on employment

Traditionally, companies reduced labour costs in order to bring down overall costs of production. This cost-cutting strategy puts pressure on labour markets. Material efficiency can be seen as an alternative strategy to reduce production costs. Cost-effective material-efficiency improvements generally increase the overall productivity of a company or a manufacturing sub-sector, which could increase wage levels. A further expansion of the manufacturing sector based on new, material-efficient products could also lead to the creation of additional jobs. However, at the same time, reduced demand for raw materials could lead to reduced employment in material extraction sectors, such as mining (see Tool 5 for more employment-oriented analyses).

In developing countries, micro-, small- and medium-sized manufacturing firms often make up the largest part of industrial employment and thus have a key role in creating jobs. As the material saving potentials are generally larger in SMEs than in bigger companies, increased material efficiency offers huge potential for increasing productivity and, as a result, employment.

2. Methodology

2.1 Module 2 on material efficiency – an overview

The material-related part of the tool as presented in this document:

- informs, as background information to the assessment of manufacturing sub-sectors, about material use and material efficiency on the economy-wide level and compares these indicators across countries;

- reflects on the extent to which the material demand of the domestic economy can be satisfied through domestic resources versus imports from abroad, which has important implications for the material security of the manufacturing sector;

- discusses the importance of the manufacturing sector in overall material use of the economy and assesses the material use of manufacturing compared to other sectors;

- introduces an approach to estimate the material requirements of manufacturing sub-sectors and thus to identify which sub-sectors contribute most to material demand of manufacturing;

- applies this approach on the level of sub-sectors in combination with value added data, in order to identify which sub-sectors generate high value added compared to their contribution to material use.

Box 1: "Material efficiency" versus "material intensity"

The two indicators of material efficiency and material intensity describe two sides of the same issue. In the context of economic-environmental assessments, material efficiency illustrates how much economic value (for example, a certain amount of value added measured in USD) is being generated per unit of material input. Material intensity is the inverse of material efficiency. The intensity indicator describes the amount of material inputs required to produce one unit of economic value. High material efficiency thus goes along with low material intensity and vice versa.

Compared to the module on energy efficiency, where data from the International Energy Agency (IEA) is suggested as the main data source for national, sector and sub-sector assessments, no such comprehensive database exists regarding material use and material efficiency. If at all, data on material consumption provided by international and national statistical institutions cover only the economy-wide level, but do not disaggregate by sectors or sub-sectors.

This tool thus implements a two-level strategy in order to overcome this data gap:

1. It is suggested to use data on the national level on material use from the most comprehensive academic online portal on global material flows, freely available at the website

www.materialflows net.[1] This website provides data on domestic extraction of raw materials, disaggregated into 12 major material groups, as well as physical imports and exports (aggregated into one group), for the time series of 1980 to 2010.

2. For assessments on the manufacturing sector and sub-sector levels, it is suggested to make use of results from economic-material use models developed in European and international research projects. These models provide data for assessing material use of the manufacturing sector as a whole and – in combination with data on value added – of manufacturing sub-sectors.

2.2. Material use and material efficiency on the national level

Definition of the indicators

The most commonly used indicator on material use on the national level is domestic material consumption (DMC). DMC is calculated as the extraction of raw materials of all four major raw material categories (see Box 2) within the borders of a country (measured in mass units, i.e. tonnes) plus imports in mass units (e.g. electronic products in kilogrammes or tonnes) minus exports in mass units. DMC thus reflects all materials directly used in the domestic economy. DMC thus is a good proxy indicator for the overall environmental pressures an economy exerts on the domestic territory, as all materials that enter the economy sooner or later are emitted back to the environment either as solid waste or emissions to air and water.

DMC is often used not only in absolute terms, but also per capita, which allows a better comparison of material consumption across a range of countries.

Box 2: The 4 major material categories

In assessments of material use, the various renewable and non-renewable raw materials are aggregated into four main material groups (Eurostat, 2013):

1. Biomass: Biotic materials from agricultural harvest, forestry or fishery activities.

2. Metal ores: Iron ores and all other non-ferrous metals (including bulk metals such as copper or aluminium as well as precious metals such as gold or platinum).

3. Minerals: This category comprises industrial minerals (such as salt, gypsum or asbestos) as well as construction minerals (such as stones and sands).

4. Fossil fuels: This category covers various forms of coal as well as crude oil and natural gas.

GDP can be set in relation to DMC, in order to illustrate the amount of economic value generated by materials used in the domestic economy (GDP/DMC). The higher this ratio, the better is the

1 Currently, there are ongoing efforts to compile a global database on national material use and material efficiency as part of activities of UNEP's International Resource Panel. This database is being built based on existing databases, most notably the one available at www.materialflows.net. The UNEP database shall be published towards the end of 2015 and will serve as the global reference database for national material flow assessments. It is suggested switching to this UNEP database once it becomes available.

material efficiency of a country. It is also interesting to calculate the GDP/DMC indicator over a time period and compare the indicator across countries of similar levels of economic development or comparable economic structures.

Main questions

Main questions that can be addressed with these indicators:

- How has the absolute material use of the national economy developed over time?
- How does the national per-capita material use compare to other countries?
- How has the material efficiency of a country developed over time and how does it compare to other countries?

Data sources

Data are provided by the online portal www.materialflows.net for all countries worldwide and in a time series from 1980 to 2010.

Indicator	Variables	Sources
Material use	Domestic material consumption / DMC (in 1000 tonnes)	www.materialflows.net
Material use per capita	DMC / capita (in tonnes)	www.materialflows.net
Material efficiency	GDP (in constant US$) / DMC	GDP: UN Statistics[1] DMC: www.materialflows.net

2.3. Material self-sufficiency

Definition of the indicator

All countries extract a range of raw materials within their own borders. However, the endowment with raw materials differs and not all materials required for production can be sourced from within the domestic territory. International trade in raw materials plays an increasingly important role in providing the raw materials required for domestic manufacturing.

Comparing the domestically available raw materials with a country's overall demand for raw materials (also called "material footprint") provides insight into its self-sufficiency or import dependency. The indicator can be broken down by major material group, i.e. biomass, metal ores, minerals and fossil fuels. This indicates to what extent the domestic demand for each group of raw materials can be met by domestic resources, and shows for which groups of raw materials the country is particularly dependent on imports.

Thus, this is an important background indicator to evaluate potential supply risks for the manufacturing sector.

Main questions

Questions that can be addressed with this indicator:

- How self-sufficient is an economy with regard to raw materials, i.e. how dependent is the overall economic system on raw material inputs from abroad?
- Which groups of raw materials show particularly low/high self-sufficiency rates?

Data sources

Data on the domestic extraction of raw materials are provided by the database www.materialflows.net (see above). Data on the overall demand for raw materials of countries (the material footprint) is not available from a database, but the result of modelling calculations, which have been carried out in the course of preparing this module for the EQuIP toolbox. Box 3 below provides more detail on the modelling exercise. The data tables in Annex 1 illustrate the results of calculations of the material self-sufficiency indicators for a large number of developing countries, expressed as a ratio of domestic extraction to overall demand. The data is also provided in the MS Excel spreadsheet accompanying this module.

Indicator	Variables	Sources
Material self-sufficiency (in %)	Domestic extraction of raw materials (in 1000 tonnes)	Domestic extraction: www.materialflows.net Overall demand: Model calculations based on data from GTAP and www.materialflows.net
	Overall demand for raw materials (in 1000 tonnes)	

Box 3: Modelling material use of sectors and sub-sectors

Models that allow calculating the overall demand for raw materials of sectors and sub-sectors combine data on the extraction of raw materials in each country worldwide (based on data from www.materialflows.net) with economic data on the sectoral structure (in the form of so-called input-output tables) as well as international trade between sectors and countries. The modelling approach is known as "environmentally extended multi-regional input-output analysis" and has been widely applied to calculate environmental and resource use indicators (see, for example, Tukker et al., 2014; Wiedmann et al., 2013).

For the calculations underlying this module, data from the Global Trade Analysis Project (GTAP) database, maintained by the Purdue University in the USA* , was applied. The technical details of the modelling approach can be found in an article in the Journal of Industrial Ecology (Giljum et al., 2014). As the latest available GTAP data is for 2007, model results are presented for that specific year. However, it is expected that modelling results for more recent years will be available soon and can then be incorporated into the analysis.

In order to allow replication of the various analyses shown in Chapter 4 for a large number of developing countries, all data that have been generated through the modelling exercise are provided both in data tables in the annexes to this document as well as in the MS Excel spreadsheet accompanying this module.

* See https://www.gtap.agecon.purdue.edu/databases/v8/

2.4. Share of material use of the manufacturing sector in total material use

Definition of the indicator

This indicator illustrates the share (in percentage) of the material use in the manufacturing sector compared to other aggregated sectors of the economy, such as agriculture, mining, transport or services. It thus provides information on the importance of the manufacturing sector in the overall economic demand for raw materials.

Also for this indicator, the above-mentioned model (see Box 3) has been applied to calculate the demand for raw materials of various aggregated economic sectors. Detailed country data are available from Annex 2 of this document as well as from the MS Excel spreadsheet accompanying this module.

Main questions

Questions that can be addressed with this indicator:

- What is the share of the manufacturing sector in demand for raw materials of the domestic economy?

- Which other economic sectors have important shares in the total demand for raw materials of the domestic economy?

Indicator

Indicator	Variables	Sources
Material use of the manufacturing sector	Demand for raw materials of the manufacturing sector as % of total raw material demand of the whole domestic economy	Model calculations based on data from GTAP and www.materialflows.net

2.5. Material use of manufacturing sub-sectors

Definition of the indicator

This indicator provides the absolute amounts of material use by manufacturing sub-sector. It can be disaggregated into the four major material categories: biomass, metal ores, minerals and fossil fuels.

The indicator is calculated by multiplying the USD value added by a manufacturing sub-sector in a specific country with the average material intensity of the sub-sector, expressed as kilogrammes material use per US$ value added.

Table 1, below, lists average material intensities (in kilogrammes material use per US$ value added) for various manufacturing sub-sectors. Data are shown for the year 2007 for the group of “low income countries”, consisting of low and low middle-income countries according to the World Bank, as well as the global average value.

It is important to note that the material intensity factors as presented in this module do not only contain the direct material requirement for the production of each sector, but also the materials required for production infrastructure (e.g. buildings, roads), as well as the material requirements of the intermediate inputs which a sub-sector purchases from other sectors (e.g. electricity and machinery).

For each manufacturing sub-sector, Table 1 shows the total material intensity across all types of raw materials. An analysis of material intensities on the level of the four major material categories is included in Chapter 4.

Table 1: Average material intensities (kg material use per US$ VA) in manufacturing sub-sectors, for country groups, all materials, 2007

	Low income countries	Global average
Food and beverages	5.21	2.77
Textiles, wearing apparel and leather products	2.51	0.91
Wood products	1.91	2.62
Paper products and publishing	1.27	1.35
Petroleum and coal products	7.39	9.53
Chemical, rubber and plastic products	6.43	8.35
Other mineral products	3.94	5.35
Basic metals	12.45	11.67
Metal products	4.64	5.32
Motor vehicles and parts	8.69	8.57
Other transport equipment	2.10	0.69
Electronic equipment	3.13	4.16
Other machinery and equipment	15.94	8.42

Source: Calculations based on GTAP and www.materialflows.net

Overall material intensities across all material groups differ significantly across manufacturing sub-sectors. On average, globally, the basic metals sub-sector is the most material intensive sub-sector, with almost 12 kg of materials required as input to produce 1 US$ of value added. Petroleum and coal products ranks second with around 9.5 kg per US$, followed by chemical, rubber and plastic products sub-sector (8.35 kg per US$). Other sub-sectors require significantly less material to generate value added, for example the food and beverages sub-sector (2.8 kg on per US$) or the textiles sub-sector (0.91 kg per US$). The contribution of the main raw material groups differ significantly between the sub-sectors (see Chapter 4 for more details).

To estimate the material use of manufacturing sub-sectors in absolute terms, the material intensities as illustrated in Table 1 for all materials (or for the four major material groups, see Chapter 4) are multiplied with data on value added in sub-sectors as provided by, for example, UNIDO's INDSTAT database.

The results deliver an estimation of the material requirements of the various manufacturing sub-sectors in a specific country, i.e. a material use profile across the manufacturing sub-sectors, which allows identifying the sub-sectors with the highest absolute material use.

Main questions

Questions that can be addressed with this indicator:

- What is each manufacturing sub-sector's share of the total material use of the manufacturing sector in a country?
- Which are the manufacturing sub-sectors with the highest material use in a country (in absolute terms)?
- How do the various manufacturing sub-sectors differ with regard to their demand for certain raw materials?

Data sources

Data on value added are provided by UNIDO INDTSTAT; material intensities are provided through modelling calculations using the GTAP and www.materialflows.net databases.

Indicator	Variable	Sources
Material use of manufacturing sub-sectors (all materials)	Manufacturing sub-sector value added (in million US$) x Material intensity of manufacturing sub-sector (in kg per US$ VA)	Value added: UNIDO INDSTAT Material intensities: Model calculations based on data from GTAP and www.materialflows.net
Sub-sector material intensities by four main material categories	Material intensity of manufacturing sub-sector by material category (in kg per US$ VA)	Model calculations based on data from GTAP and www.materialflows.net
Sub-sector material use by four main material categories	Material use of sub-sectors (in 1000 tonnes) / Material use of manufacturing sector	Value added: UNIDO INDSTAT Material intensities: Model calculations based on data from GTAP and www.materialflows.net

3. Analysis

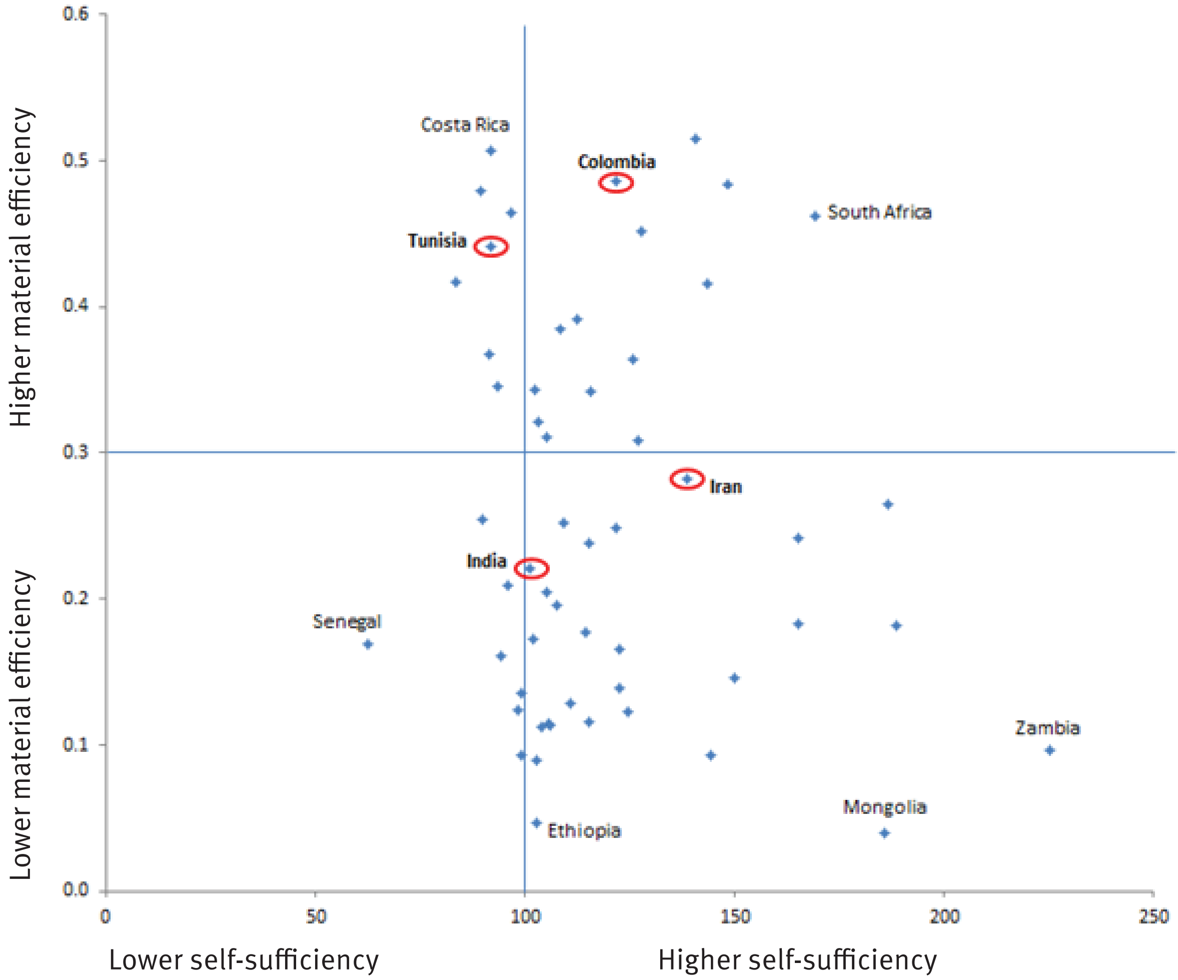
In this section, we illustrate how the indicators presented in the preceding section on methodology can be applied for the assessment of material use, efficiency and self-sufficiency in various developing countries on the national, sector and sub-sector levels. Hence, with the aim of determining priorities for enhanced resilience and competitiveness, this analysis provides a deeper understanding of where a country stands in terms of its material use, efficiency and self-sufficiency, as well as of the material use of the manufacturing sector and its sub-sectors.

3.1 Overview: material efficiency and material self-sufficiency

In the introduction, it was argued that achieving high levels of material efficiency can result in multiple win-win situations; for instance, creating positive economic impulses, assisting in diversifying export structures, stimulating the labour market, or positively impacting the environment. We therefore start with an investigation of how various developing countries perform with regard to the two main indicators, material efficiency and material self-sufficiency.

Figure 3 plots a number of countries according to material self-sufficiency ratio on the x-axis and material efficiency on the y-axis. In order to group the large number of countries, we define four quadrants, dividing both axes into two sections. For separating countries with low versus high material self-sufficiency, the limit is set at 100, i.e. a situation in which all raw materials required by the national economy can in principle be supplied by domestic resources. All countries which have a value below 100 have lower material self-sufficiency, i.e. their domestic demand in one year exceeds the domestic raw material extraction in that year, whereas values above 100 indicate that the domestic production exceeds the domestic demand for materials.

Figure 3: Material efficiency and material self-sufficiency, selected countries, 2007



Source: www.materialflows.net; model calculations based on GTAP database

On the y-axis, the material efficiency of the overall economy is illustrated, calculated as GDP divided by domestic material consumption (DMC). The line dividing countries with low material efficiency from those with high material efficiency is drawn at 0.3 kg of material consumption per US$ of GDP. Drawing the line at the value of 0.3 primarily serves the purpose of defining four quadrants to identify example countries with different situations.

Figure 3 illustrates that developing countries face very different material self-sufficiency and material efficiency levels. In terms of of all raw materials required by the economy, self-sufficiency values range from around 60 to more than 200 (however, situations can be very different for single material groups; see section 4.3).

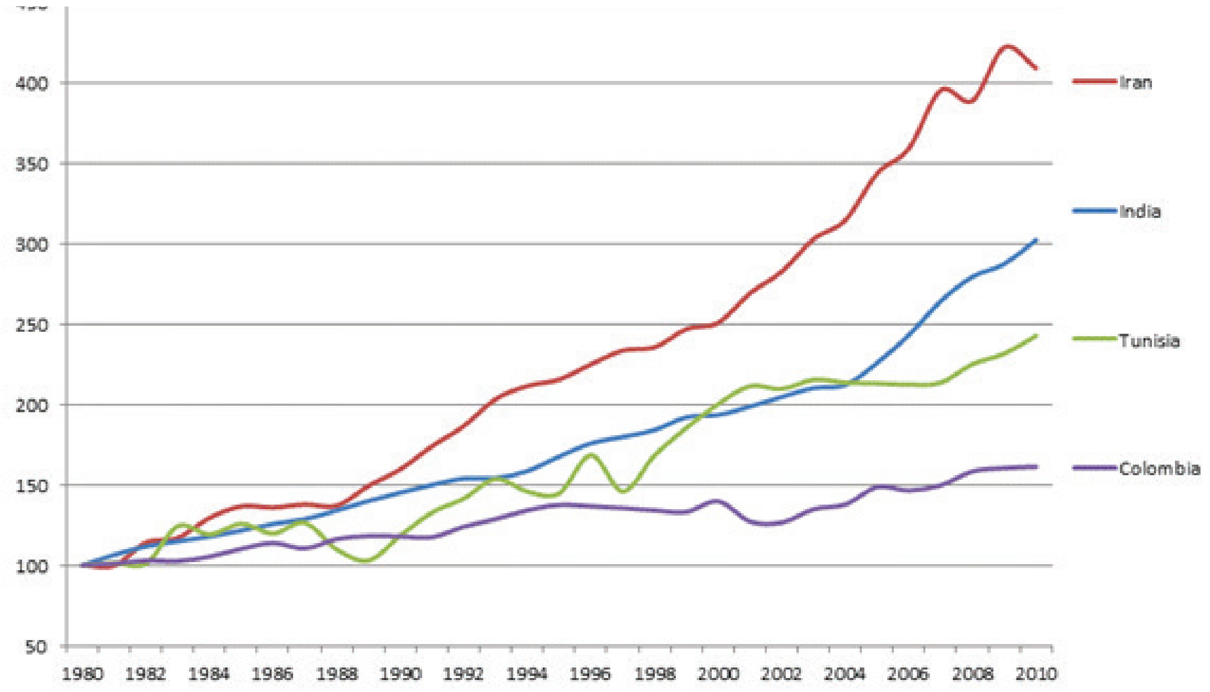
Among developing countries, material efficiency is generally lowest for African and some Asian countries with values below 0.1 US$ per kg of material consumption. Higher values for developing countries can be observed for some Latin American countries such as Colombia, Costa Rica or Panama with values between 0.5 and 0.6 US$.

From the countries included in the analysis we chose four case study countries to apply and illustrate the indicators discussed above: Colombia, India, Iran, and Tunisia. The selection of these four case study countries in this module was guided by several criteria. The first was the availability of data on manufacturing value added from UNIDO's INDSTAT database, which are needed to perform the sub-sector level calculations (see chapter 4.5). Second, from these developing countries, four examples with different profiles regarding material efficiency and material self-sufficiency were selected. Three of these (India, Tunisia and Colombia) are also case study countries in the energy efficiency module.

3.2 Material use (absolute and per capita)

The analysis of the four case study countries starts on the economy-wide level with an assessment of the overall material use, both in absolute and per-capita terms. Figure 4 illustrates the trends in absolute material use in the four example countries between 1980 and 2010, with the 1980 level indexed at 100.

Figure 4: Domestic Material Consumption (DMC), 1980-2010, 1980=100



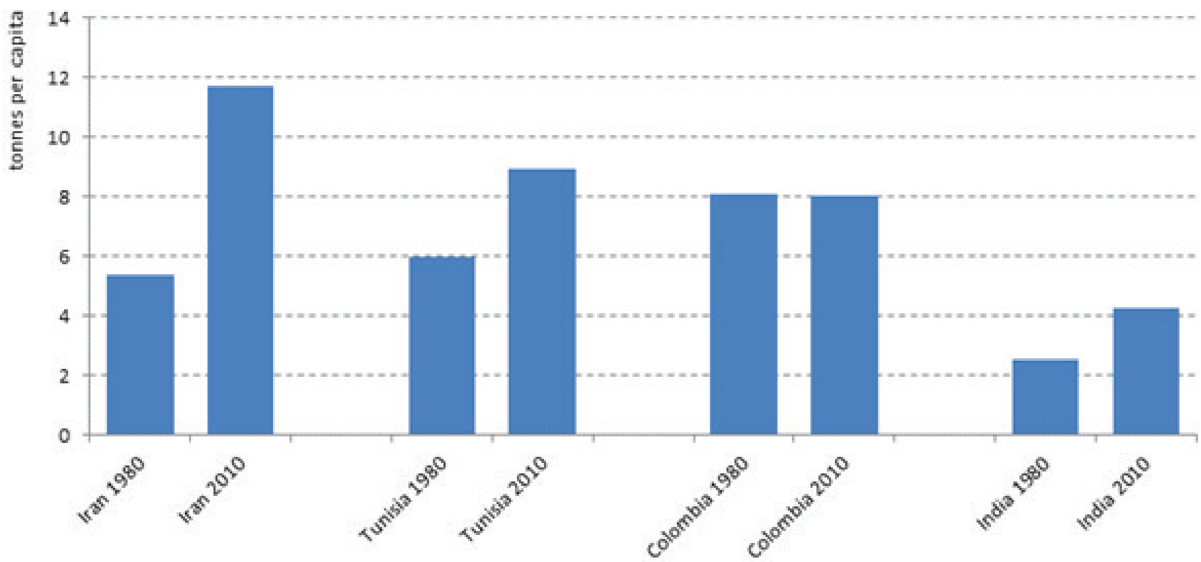
Source: www.materialflows.net

Material consumption in absolute terms has grown in all case study countries. Growth was most notable in Iran at more than 300% since 1980. Also India's economy-wide material consumption more than tripled in the past 30 years. Growth in absolute terms was less pronounced in Colombia, but still more than 60%. The numbers imply that continued economic development and rising levels of affluence in these countries also translated into a growth of the physical economy. Improvements in material efficiency that were observed in India, Tunisia and Colombia in the respective time period (see Figure 5 below) were thus not strong enough to slow down overall growth of absolute material use.

Figure 5 compares the per-capita material consumption values for the years 1980 and 2010.

Per-capita material consumption levels are very different in the four case study countries. In 2010, values ranged from almost 12 tonnes per capita in Iran to 4.2 tonnes per capita in India. Growth in per-capita consumption in the observed time period was strongest in Iran (+118%), followed by India (+70%) and Tunisia (+50%). In Colombia, per-capita material consumption values did not change over the past 30 years, which implies that the increase in absolute material consumption of the Colombian economy (see Figure 3 above) was mainly driven by population growth.

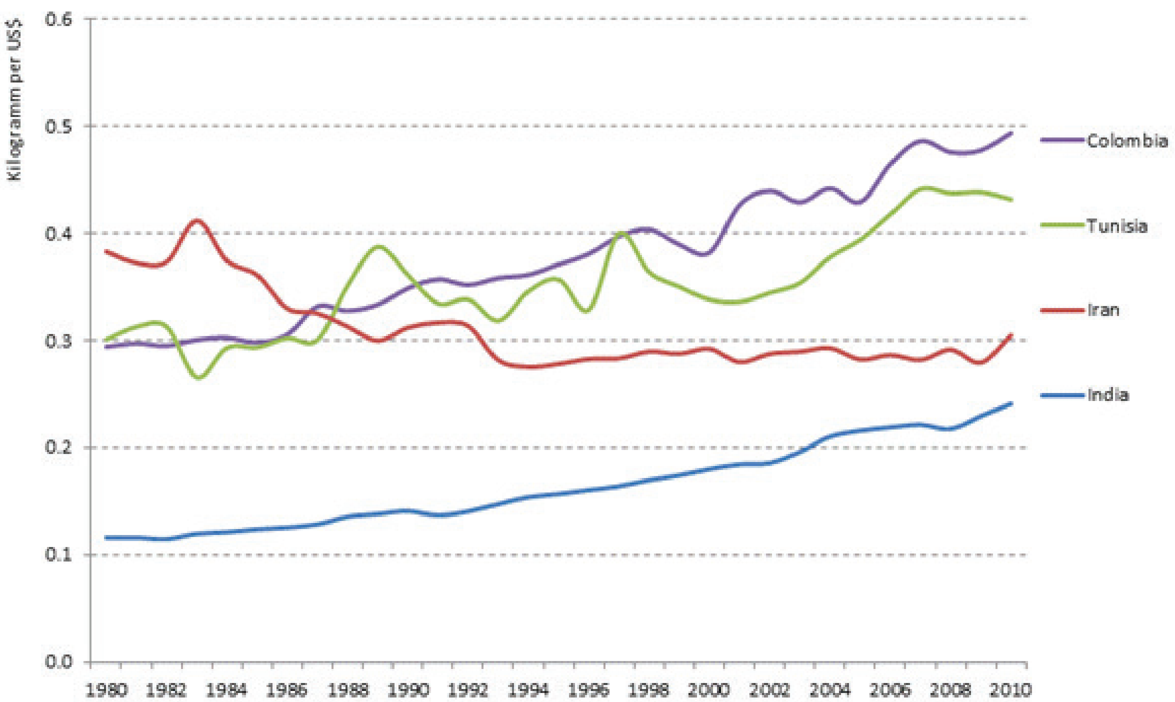
Figure 5: Comparison of DMC per capita, 1980 and 2010



Source: www.materialflows.net

Data on material use can be linked to GDP data in order to visualise the amount of economic value generated per unit of material. In Figure 6 illustrates the time development of material efficiency from 1980 to 2010, calculated as GPD over DMC.

Figure 6: Trends in material efficiency, 1980-2010



Source: www.materialflows.net

Trends of material efficiency in the four countries show significant differences. In all countries except Iran, material efficiency increased, i.e. more economic value was generated per kilogramme of material consumption in the year 2010 compared to the year 1980. The strongest increase can be observed for India, which doubled its material efficiency from 0.12 US$ per kg to 0.24 US$. However, in 2010, India was still the case study country with the lowest overall efficiency. Significant improvement was also achieved in Colombia (+68%). The improved material efficiency in these three countries can be regarded as a positive trend, which may have been influenced by various factors, including structural shifts in the economy towards higher value-added manufacturing and service sectors or the application of more material-efficient technologies. However, the material efficiency improvements were overcompensated by economic growth, leading to rising absolute levels of material consumption of the whole economy and thus rising pressures on the environment.

The only example country in which material efficiency decreased was Iran, indicating that material consumption on the economy-wide level was growing even more rapidly than GDP. This trend is mainly driven by the growing extraction of fossil fuels, with the mining sector clearly dominating the sector material consumption (see section 4.5).

3.3 Material self-sufficiency

An evaluation of the degree of material self-sufficiency can be performed by comparing the raw materials extracted within a country's borders with the overall amount of raw materials required to maintain the domestic production system. Annex 1 provides an overview of material self-sufficiency ratios for the four major material categories of biomass, non-metallic minerals, metal ores, and fossil fuels. Table 2 extracts the information for the four example countries.

Table 2: Material self-sufficiency ratios for case study countries, % ratios, 2007

Country	Biomass	Non-metallic minerals	Metals	Fossil fuels
India	102	110	112	79
Iran	90	125	82	278
Tunisia	94	93	15	92
Colombia	103	94	15	406

Note: when domestic raw material extraction equals the domestic demand for raw materials, the number is 100%

Source: www.materialflows.net; own calculations

Table 2 illustrates that all four case study countries have ratios around 100 for the categories of biomass and non-metallic minerals. This implies that regarding biomass and minerals, the entire (or almost entire) domestic demand could potentially be met by domestic extraction of materials. For these two raw material categories, the situation in the four example countries can be generally regarded as uncritical, although specific shortages and import dependencies could arise with regard to certain raw materials within the aggregated group.

In the sub-category of metal ores, Tunisia and Colombia face the lowest self-sufficiency ratio, with domestic extraction of metal ores being only 15% of the total demand for metal ores of the domestic economy. Manufacturing sub-sectors dependent on metal ores therefore face a very critical situation these countries. In Iran, domestic production of metal ores is around 20% lower than domestic demand.

With regard to fossil fuels, the situation is very different, with Colombia and Iran producing far more within their own territories than demanded by the domestic economy, thus serving as net-exporters to other countries. With a self-sufficiency rate of 79%, the supply of fossil fuels is more critical for India.

3.4 Material use of the manufacturing sector

Below, Figure 7 illustrates the importance of the manufacturing sector compared to other economic activities in the four example countries. It shows the material used by various aggregated economic sectors to produce their respective outputs. It can be seen that for all four countries, the manufacturing sector is one of the main contributors to overall material use, contributing between 18% and 32% of the total.

The importance of agriculture to the Indian economy is reflected by its significant share (34%) of total material use. Manufacturing ranks second with 26%. In economic terms, India has a significant service sector, but these activities are much less material-intensive, and thus the aggregated contribution of services to total material use is only 2%. In Iran, the major contribution of the mining sector stands out (32%), resulting mainly from the extraction of fossil fuels. With 29%, manufacturing also ranks second in Iran. In Tunisia, the largest sector contribution in 2007 came from energy provision and construction (32%), followed by mining (28%). With only 18%, the share of the manufacturing sector is smaller in Tunisia than in the other example countries. Agriculture is the number one contributor to total material use in Colombia (34%), followed closely by manufacturing (32%).

Despite differences between countries, it can be concluded that the manufacturing sector generally plays a significant role in determining the overall demand for materials and thus deserves closer attention.

Figure 7: Share of manufacturing sector material use compared to other aggregated sectors, 2007

Source: Model calculations based on GTAP and www.materialflows.net

3.5 Material use of manufacturing sub-sectors

The final step of the analysis focuses on the level of manufacturing sub-sectors. The suggested analytical steps allow determining (a) each domestic manufacturing sub-sector's share of total manufacturing material use, (b) the absolute levels of material use in various manufacturing sub-sectors, and (c) the composition of material use in terms of the four major raw material groups.

All indicators in this chapter are calculated by multiplying the sub-sector value added (in US$) with average data on material intensities (in kilogramme materials per US$) – see Section 2.5 on methodology for more details.

Sub-sector value added and material use

Multiplying the value added by a manufacturing sub-sector with its material intensity coefficient from Table 1 (covering all raw materials) yields an estimate of the sub-sector's absolute material use. Later in this section, material-specific intensity factors will also be applied.

This analysis identifies those manufacturing sub-sectors with the highest absolute demand for raw materials. As the first step, Table 3 illustrates the structure of value added across manufacturing sub-sectors in the four example countries, extracted from UNIDO's INDSTAT database.

Table 3: Value added of manufacturing sub-sectors in example countries, 2007, in million US$ and % of total manufacturing value added

Manufacturing sub-sector	India		Iran		Tunisia		Colombia	
Food and beverages	11349	9%	2835	8%	1187	18%	7782	27%
Textiles, wearing apparel and leather	10010	8%	1173	3%	1724	26%	2302	8%
Wood products	262	0.2%	122	0.3%	194	3%	145	0.5%
Paper products and publishing	3529	3%	441	1%	125	2%	2047	7%
Petroleum and coal products	17209	13%	3890	11%	159	2%	4566	16%
Chemical, rubber and plastic products	21015	16%	7482	21%	748	11%	4874	17%
Other mineral products	8773	7%	3233	9%	622	10%	2210	8%
Basic metals	24107	19%	7035	19%	255	4%	2224	8%
Metal products	4620	4%	1570	4%	376	6%	629	2%
Motor vehicles and parts	7186	6%	5093	14%	268	4%	930	3%
Other transport equipment	2824	2%	309	1%	13	0.2%	270	1%
Electronic equipment	7979	6%	1244	3%	675	10%	494	2%
Other machinery and equipment	8909	7%	1807	5%	200	3%	632	2%

Source: UNIDO INDSTAT database

In India, several sub-sectors play a very important role, with basic metals contributing the highest share of total manufacturing value added (19%), followed by chemical, rubber and plastic products (16%) and petroleum and coal products (13%). In Iran, the same sectors contribute most to the total value added, in addition to motor vehicles and parts (14%). The structure is less diversified in both Tunisia and Colombia. In Tunisia two sectors combined (textiles, wearing apparel and leather products, and food and beverages) contribute 44% to the total. In Colombia, food and beverages alone contributes 27%, and together with chemical, rubber and plastic products, as well as petroleum and coal products, accounts for almost 60% of Colombia's value added in the manufacturing sector.

In the second step, the data on value added are multiplied with the material intensity factors in order to estimate the material use of each manufacturing sub-sector. Using the material intensity factors for all raw materials (see Table 1), the absolute amounts of material use as well as the contribution of each sub-sector to the total material use of the manufacturing sector can be calculated (see Table 4).

Table 4: Material use of manufacturing sub-sectors in example countries, 2007, in 1000 tonnes and % of total manufacturing material use

Manufacturing sub-sector	India		Iran		Tunisia		Colombia	
Food and beverages	59116	6%	14768	5%	6183	19%	40538	23%
Textiles, wearing apparel and leather	25152	3%	2948	1%	4332	14%	5785	3%
Wood products	500	0.1%	233	0.1%	369	1%	276	0.2%
Paper products and publishing	4482	0.5%	560	0.2%	159	0.5%	2600	1%
Petroleum and coal products	127105	13%	28734	10%	1176	4%	33722	19%
Chemical, rubber and plastic products	135179	14%	48129	17%	4809	15%	31355	18%
Other mineral products	34582	4%	12744	5%	2452	8%	8711	5%
Basic metals	300178	32%	87606	31%	3178	10%	27694	16%
Metal products	21424	2%	7279	3%	1744	5%	2919	2%
Motor vehicles and parts	62459	7%	44269	16%	2327	7%	8083	5%
Other transport equipment	5932	1%	650	0.2%	28	0.1%	566	0.3%
Electronic equipment	24959	3%	3892	1%	2112	7%	1545	1%
Other machinery and equipment	141993	15%	28799	10%	3184	10%	10071	6%

Source: Calculations based on GTAP and www.materialflows.net

In India, the basic metal sector clearly dominates the demand for materials, contributing 32% to the aggregated manufacturing sector total for 2007. Other machinery and equipment ranks second (15%), closely followed by the chemical and plastics industry (14%) and the production of petroleum and coal products (13%). The basic metals sub-sector also contributes the highest share to the total in Iran (31%), followed by chemical, rubber and plastic products (17%) and motor vehicles (16%). In contrast, sub-sectors which depend mainly on renewable materials play a bigger role in Tunisia: food and beverages (19%) and textiles (14%). Still, chemicals, rubber and plastics is of high importance for material use (15%). In Colombia, too, food and beverages contribute most to material demand of manufacturing (23%). Petroleum and coal products rank second (19%) and chemical, rubber and plastic products third (18%).

From the perspective of greening industries and sustainable industrial development, it is preferable to specialise in those manufacturing sub-sectors with high value added, yet low material use. To see which sub-sectors those are, Table 5 combines information on value added and material use.

Table 5: Shares of value added and material use of manufacturing sub-sectors in example countries, 2007, in % of manufacturing total

Manufacturing sub-sector	India		Iran		Tunisia		Colombia	
	VA	MU	VA	MU	VA	MU	VA	MU
Food and beverages	9%	6%	8%	5%	18%	19%	27%	23%
Textiles, wearing apparel and leather	8%	3%	3%	1%	26%	14%	8%	3%
Wood products	0.2%	0.1%	0.3%	0.1%	3%	1%	0.5%	0.2%
Paper products and publishing	3%	0.5%	1%	0.2%	2%	0.5%	7%	1%
Petroleum and coal products	13%	13%	11%	10%	2%	4%	16%	19%
Chemical, rubber and plastic products	16%	14%	21%	17%	11%	15%	17%	18%
Other mineral products	7%	4%	9%	5%	10%	8%	8%	5%
Basic metals	19%	32%	19%	31%	4%	10%	8%	16%
Metal products	4%	2%	4%	3%	6%	5%	2%	2%
Motor vehicles and parts	6%	7%	14%	16%	4%	7%	3%	5%
Other transport equipment	2%	1%	1%	0.2%	0.2%	0.1%	1%	0.3%
Electronic equipment	6%	3%	3%	1%	10%	7%	2%	1%
Other machinery and equipment	7%	15%	5%	10%	3%	10%	2%	6%

Source: UNIDO INDSTAT database (value added) and calculations based on GTAP and www.materialflows.net (material use)

Table 5 illustrates that some sub-sectors have a higher demand for materials, but contribute less to the generation of manufacturing value added than others. That is, the percentage in the left column is smaller than the percentage in the right column for each country. The basic metals sector is the most notable example with a similar pattern across all four countries. In India, for example, the basic metals sub-sector contributes 32% to material demand, but generates only 19% of manufacturing value added. Percentage shares of basic metals are very similar for Iran and in the other two example countries, material use for basic metals also exceeds the share of value added by far.

Other sub-sectors show a more favourable pattern: high value added and low material use. For example, the three sub-sectors food, textiles and electronics generally have a higher relative contribution to total value added than to material use. That is, the percentage in the left column is higher than the one in the right column, which is positive the perspective of greening manufacturing industries.

Sub-sector material intensities by four main material categories

Material intensity data are available not only for the aggregate of all materials (see Table 1), but also for the four major material categories. This allows analysing the importance of certain major materials for each of the manufacturing sub-sectors. Tables 6-9 illustrate material intensities per sub-sector with regard to each group specifically.

Table 6: Average biomass intensities (kg material use per US$ VA) in manufacturing sub-sectors, for country groups, 2007

	Low income countries	Global average
Food and beverages	4.55	2.34
Textiles, wearing apparel and leather products	1.49	0.49
Wood products	1.29	1.84
Paper products and publishing	0.66	0.47
Petroleum and coal products	0.14	0.14
Chemical, rubber and plastic products	1.51	1.29
Other mineral products	0.18	0.16
Basic metals	0.25	0.21
Metal products	0.21	0.22
Motor vehicles and parts	0.79	0.63
Other transport equipment	0.15	0.05
Electronic equipment	0.36	0.40
Other machinery and equipment	0.90	0.44

Source: Calculations based on GTAP and www.materialflows.net

The highest demand for biomass per unit of value added is found in the food and beverages sector, with a global average of 2.34 kg of input per US$ and an average of 4.55 kg in low income countries. Biomass is also used intensively by the textiles, wood and chemical sub-sectors. Contributions of biomass to other sub-sectors are small.

Table 7: Average non-metallic mineral intensities (kg material use per US$ VA) in manufacturing sub-sectors, for country groups, 2007

	Low income countries	Global average
Food and beverages	0.28	0.20
Textiles, wearing apparel and leather products	0.45	0.19
Wood products	0.35	0.43
Paper products and publishing	0.22	0.38
Petroleum and coal products	0.73	0.80
Chemical, rubber and plastic products	2.47	3.30
Other mineral products	2.84	4.19
Basic metals	7.12	7.50
Metal products	2.89	3.41
Motor vehicles and parts	4.83	5.14
Other transport equipment	1.28	0.42
Electronic equipment	1.82	2.54
Other machinery and equipment	10.62	5.61

Source: Calculations based on GTAP and www.materialflows.net

Material intensities for non-metallic minerals are determined to a large extent by the construction of infrastructure for manufacturing, such as buildings or transport infrastructure. As all manufacturing sub-sectors need these, use of non-metallic minerals is spread across a wide range of manufacturing sub-sectors. The highest requirements relative to value added are for the basic metals, other mineral products and metal products sub-sectors. Also, the production of electronic equipment uses significant non-metallic mineral resources.

Table 8: Average metal ore intensities (kg material use per US$ VA) in manufacturing sub-sectors, for country groups, 2007

	Low income countries	Global average
Food and beverages	0.03	0.02
Textiles, wearing apparel and leather products	0.03	0.01
Wood products	0.04	0.05
Paper products and publishing	0.03	0.02
Petroleum and coal products	0.10	0.10
Chemical, rubber and plastic products	0.12	0.14
Other mineral products	0.05	0.05
Basic metals	3.13	2.27
Metal products	0.80	0.83
Motor vehicles and parts	1.44	0.99
Other transport equipment	0.27	0.08
Electronic equipment	0.29	0.29
Other machinery and equipment	1.75	0.85

Source: Calculations based on GTAP and www.materialflows.net

Use of metallic resources is highest in metal-processing sectors, i.e. the basic metals sub-sector (around 2.3 kg of metal inputs per US$ of value added), followed by the metal products and motor vehicles sub-sectors. In other sub-sectors, demand for metallic minerals is rather low. It is almost negligible in biomass-oriented sub-sectors (food, textiles, wood, paper).

Table 9: Average fossil fuel intensities (kg material use per US$ VA) in manufacturing sub-sectors, for country groups, 2007

	Low income countries	Global average
Food and beverages	0.35	0.21
Textiles, wearing apparel and leather products	0.54	0.22
Wood products	0.23	0.31
Paper products and publishing	0.37	0.48
Petroleum and coal products	6.42	8.49
Chemical, rubber and plastic products	2.34	3.61
Other mineral products	0.88	0.95
Basic metals	1.94	1.69
Metal products	0.74	0.85
Motor vehicles and parts	1.64	1.81
Other transport equipment	0.40	0.14
Electronic equipment	0.66	0.93
Other machinery and equipment	2.67	1.51

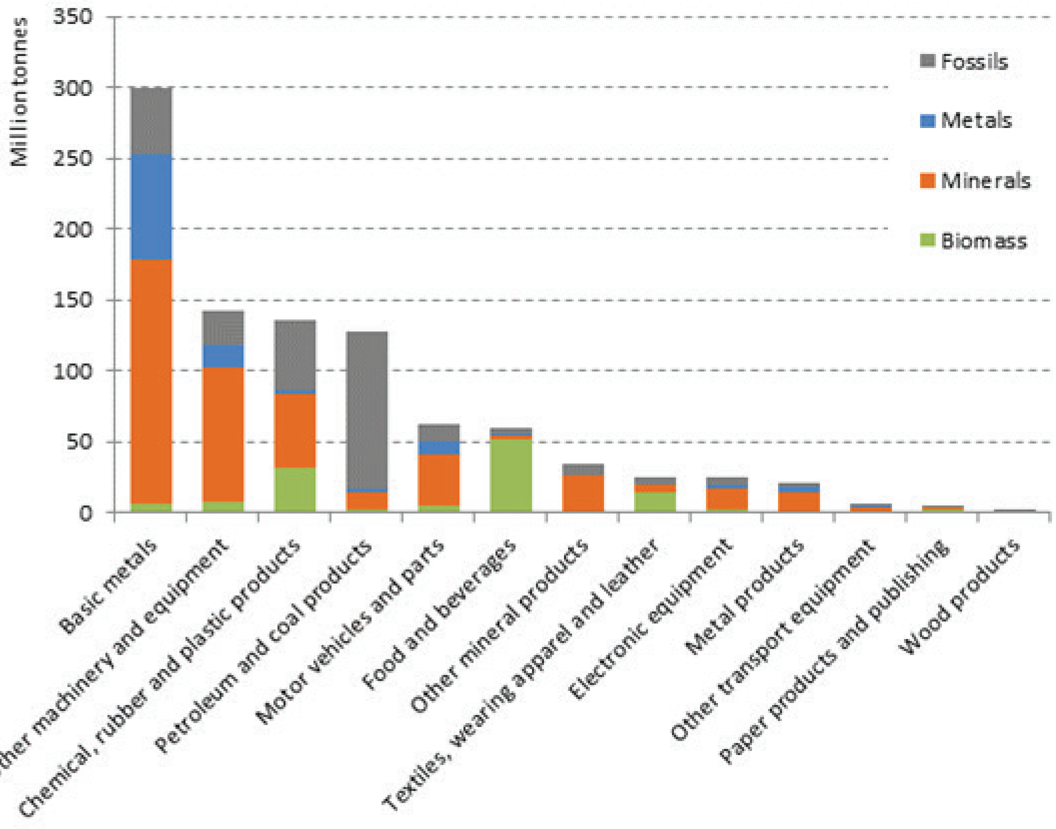
Source: Calculations based on GTAP and www.materialflows.net

Not surprisingly, fossil fuel inputs are most pronounced for petroleum and coal products. Crude oil is also used extensively in the chemical, rubber and plastics industry. Also, the basic metal and motor vehicle sub-sectors have high use of fossil fuels for each dollar value added.

Sub-sector material use by four main material categories

The detailed material intensity information for the four aggregated material groups (see Tables 6-9 above) can be used to show the material composition on the sub-sector level. Figures 8-11 do so for our four example countries, ranking manufacturing sub-sectors by absolute material use, while also illustrating the contribution of the four material groups to the sector total.

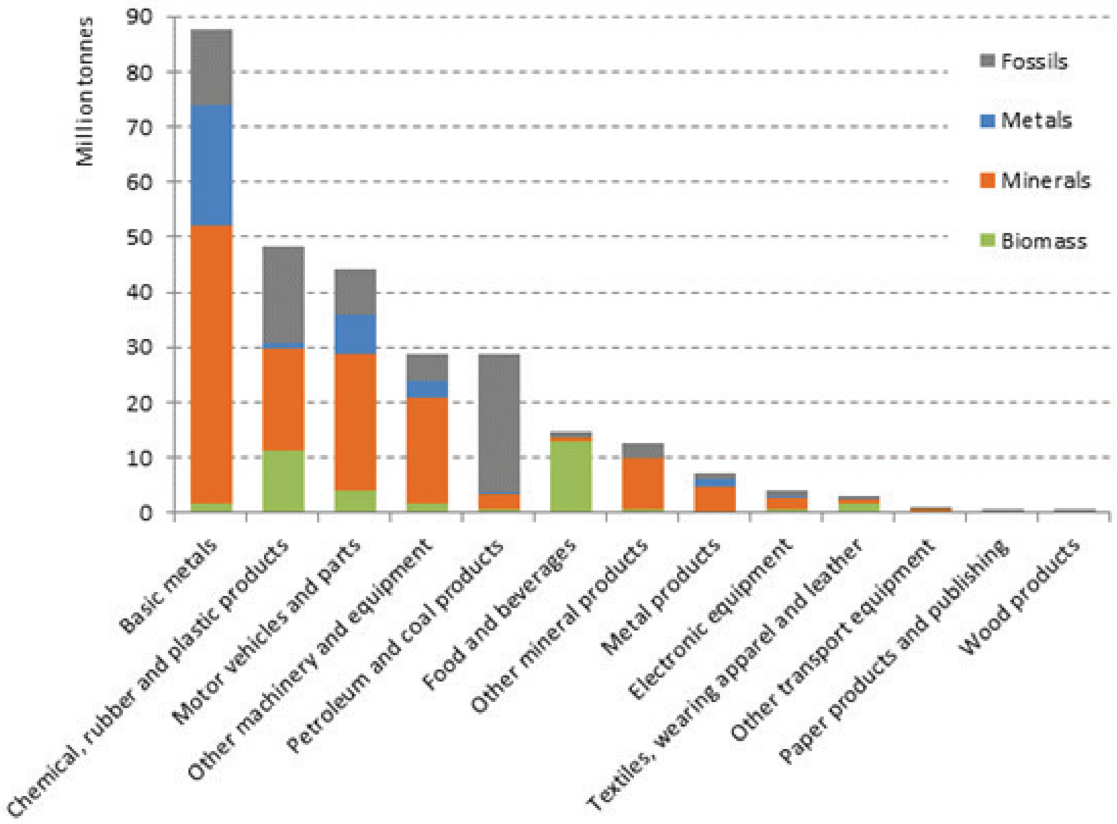
Figure 8: Material use of manufacturing sub-sectors in India, million tonnes, 2007



Source: Model calculations based on GTAP and www.materialflows.net

Basic metals, as the sub-sector with the highest overall material use in absolute terms in India, requires significant amounts of all non-renewable material categories – not just metals, but also non-metal minerals and fossil fuels. Some sub-sectors rely primarily on one material group, such as petroleum and coal on fossil fuels, and food and beverages on biomass. Sub-sectors which rely heavily on fossil fuel inputs are potentially in a situation of supply risk, as India's self-sufficiency ratio is below 100% for this material category only (see Table 2).

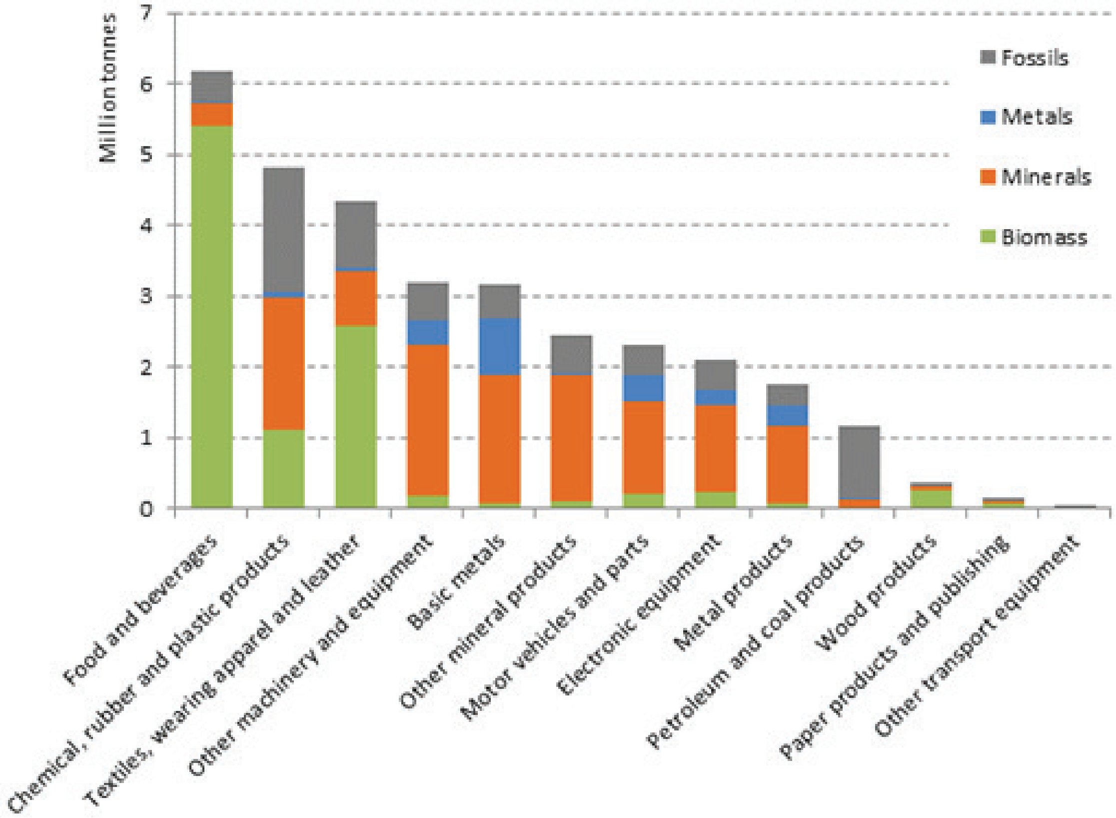
Figure 9: Material use of manufacturing sub-sectors in Iran, million tonnes, 2007



Source: Model calculations based on GTAP and www.materialflows.net

In Iran, too, the basic metals sub-sector is the most material-intensive, with also its proportions of the main material categories similar to India. Other patterns, e.g. for petroleum and coal or food and beverages, are also comparable to India. Chemical, rubber and plastic products in Iran have a remarkably high share of fossil fuel inputs. In terms of material self-sufficiency (see Table 2), Iran faces only minor potential supply risks in metals and biomass. Therefore, inputs for the basic metals and food and beverages sub-sectors may become problematic.

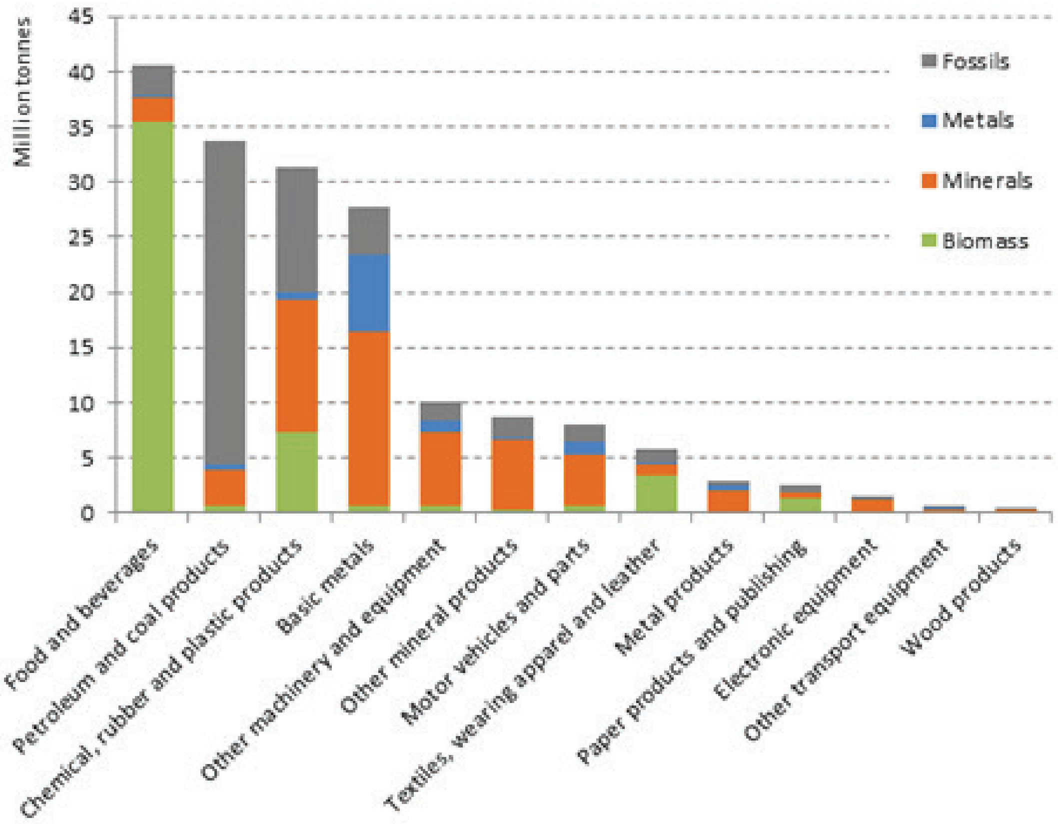
Figure 10: Material use of manufacturing sub-sectors in Tunisia, million tonnes, 2007



Source: Model calculations based on GTAP and www.materialflows.net

Biomass-based materials play a very important role in Tunisian manufacturing, particularly for food and beverages as well as textiles, wearing apparel and leather. Chemicals and machinery are also major sub-sectors in terms of material use. As shown in Table 2, Tunisia relies on net imports for all categories of raw materials (its demand is higher than domestic production). This is particularly critical when it comes to metal ores, for which only a small fraction of demand is satisfied through domestic sources. Thus, sub-sectors such as basic metals and machinery and equipment face potential supply risks.

Figure 11: Material use of manufacturing sub-sectors in Colombia, million tonnes, 2007



Source: Model calculations based on GTAP and www.materialflows.net

In Colombia, food and beverages is the sub-sector with the highest overall material demand (mainly biomass). The petroleum and chemical sub-sectors respectively come second and third. Given the high domestic production of fossil fuels (see positive self-sufficiency ratio in Table 2), the demand of these sectors can largely be supplied from domestic sources. Yet Colombia, like Tunisia, lacks metal mines, resulting in very high import ratios and a potential supply risk for the basic metals sub-sector.

3.6 Conclusions on the analysis of material efficiency for greening industries

The analysis presented in this section is based on the most advanced data and indicators currently available with regard to material use, both on the economy-wide level as well as for the manufacturing sector and its sub-sectors.

The analysis reveals that for all four example countries, material efficiency is increasing on the economy-wide level: an ever higher amount of economic value is generated per unit of material input. At the same time, absolute material use is going upwards, indicating that economic growth exceeds the efficiency gains. From an environmental perspective, this development trend is problematic, as higher material consumption also means higher production of waste and pollution in the affected countries. More effort to accelerate material efficiency improvements is therefore needed across many developing countries.

The analysis also illustrates the significance of the manufacturing sector (and sub-sectors) in the overall demand for materials, making it crucial for the transformation into a material-efficient and competitive economy.

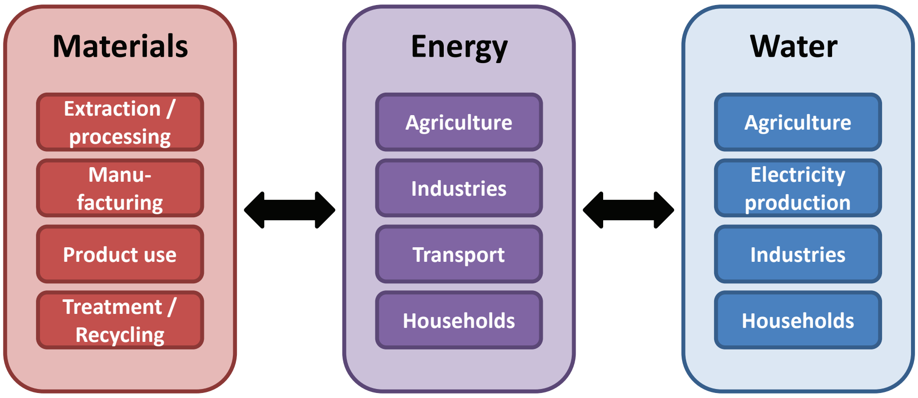
Self-sufficiency rates of material provision vary across developing countries, as their endowments with material reserves are very different. While most developing countries possess sufficient sources of biomass and construction minerals, import dependencies regularly occur with regard to metal ores as well as fossil fuels. Manufacturing sub-sectors in countries where imports provide most of their material inputs are therefore vulnerable with regard to the stability of supply and should develop strategies to maintain access to the required raw materials on international markets.

From the perspective of greening industries, it is desirable to develop those manufacturing sub-sectors which generate a high proportion of value added compared to their proportion of material use. Decision makers in developing countries can use the tools and analyses introduced in this module to assess for which manufacturing sub-sectors the ratio between value added and material use is favourable, and for which it is unfavourable. This is important information for designing future development strategies towards a resource-efficient manufacturing sector.

4. The material efficiency module in relation to other categories of natural resource use

The use of raw materials is closely related to other categories of natural resources such as energy and water. Those other categories are addressed in other modules of this tool. Figure 12 shows a schematic representation of the interlinkages between the three resource input categories.

Figure 12: The interlinkages between different categories of resource use



Source: adapted from BIO IS et al. (2012)

Raw material use is closely related to the use of energy, as energy is required in all stages of a product's life-cycle: from extraction and processing of raw materials, through manufacturing and transport to the use phase, waste treatment and recycling (see Tool 6, Module 1 on energy efficiency). Close interlinkages can also be observed with water use, as water is a key input for the production of renewable raw materials, for energy production as well as an input of manufacturing processes. On the flip side, building infrastructure for the abstraction, distribution and treatment of water also requires raw materials.

Increasing material efficiency in manufacturing industries will therefore have impacts on other resource categories. Less material-intensive production technologies and the production of resource-light products will reduce energy demands throughout the whole life-cycle. However, a shift towards renewable raw materials and renewable biomass-based energy, i.e. from agricultural production, could increase the demand for water, e.g. for irrigation purposes.

5. The material efficiency module in relation to other pillars of the EQuIP toolbox

The Greening Industry tool, as the "environmental pillar" of the EQuIP toolbox, has to be seen in close interrelation and interaction with its economic and social pillars, as activities in one pillar often affect performance in the others. Hence, specific economic, social and environmental trends go hand in hand with each other.

Industrial and export upgrading

- This module has clear links to EQuIP Tool 3 on industrial and export upgrading. The most material-intensive manufacturing sub-sectors (e.g. basic metals), are generally also those characterised by the lowest level of processing, thus contributing relatively little to the creation of value added and enhanced technological sophistication.

- Strategies to upgrade industrial production and exported goods on the macro, sub-sector and product level as described in Tool 3 will therefore also have positive impact on the material efficiency of the domestic economy and the manufacturing sub-sector.

Diversification

- The material efficiency on the economy as well as sub-sector levels are also closely related to the issue of diversification, as analysed in EQuIP Tool 4. In many cases, low levels of diversification go along with a specialisation in a few resource-intensive production and export activities, such as mining and export of unprocessed metal ores or fossil fuels.

- Often, developing strategies to diversify domestic economic structures towards more highly processed products with higher value added also contributes positively to material efficiency of the various sub-sectors.

Links to other pillars of the toolkit include:

Industrial growth/competitiveness:

- Material efficiency can be a driver of economic growth, as it reduces production costs and increases the international competitiveness of manufacturing companies. This is particularly important for SMEs, which often have a larger productivity gap to international productivity benchmarks.

- Industrialisation strategies to diversify export structures away from exporting unprocessed raw materials towards processed materials and semi-manufactured products with higher value added accelerate growth and reduce vulnerabilities of the domestic economy to price volatilities on commodity markets.

Enhanced technological sophistication:

- The adoption (or even domestic development) of new production technologies with higher material efficiency provides a positive impulse to technological sophistication.

- The development of products with higher material efficiency, i.e. dematerialised products, is a driver of innovation with increasing importance on international markets, as the demand for greener products will increase in the future.

Health and wellbeing

- Depending on the rate of efficiency increases, a more efficient use of natural resources could lead to a decrease in overall resource use and, as a consequence, to less pressure on the environment. For example, this could result in a reduction of waste produced as well as a reduced threat to ecosystems due to resource extraction and processing, with positive indirect impacts on human health and healthcare costs.

Externalities of resource use

- Extraction and processing of natural resources often take place in politically instable areas with weak institutions not able to provide the necessary framework for an economically, socially and environmentally sound exploitation. As a consequence, resource exploitation often goes along with (sometimes armed) conflicts and/or environmental destruction. Increased resource efficiency can lower the demand for resources stemming from unstable settings, reducing the negative (social) externalities of resource extraction.

Tool

6

Greening Industry - Module 2: Material Efficiency

6. References and Further Reading

Deloitte, 2013. Global Manufacturing Competitiveness Index 2013. Deloitte Global Services Limited.

Ecorys, 2011. Study on the Competitiveness of the European Companies and Resource Efficiency. Ecorys, Rotterdam.

EIO, 2011. Closing the eco-innovation gap. An economic opportunity for business. Eco-Innovation Observatory, Brussels.

Eurostat, 2013. Economy-wide Material Flow Accounts (EW-MFA). Compilation Guide 2013. Statistical Office of the European Communities, Luxembourg.

Giljum, S., Bruckner, M., Martinez, A., 2014. Material Footprint Assessment in a Global Input-Output Framework. Journal of Industrial Ecology. DOI: 10.1111/jiec.12214.

Lee, B., Preston, F., Kooroshy, J., Bailey, R., Lahn, G., 2012. Resources Futures. A Chatham House Report. The Royal Institute of International Affairs, London.

Steger, S., Bleischwitz, R., 2009. Decoupling GDP from resource use, resource productivity and competitiveness, in: Bleischwitz, R., Welfens, P., Zhang, Z. (Eds.), Sustainable growth and resource productivity: economic and global policy issues Greenleaf Publishing Limited, pp. 172-193.

Tukker, A., Bulavskaya, T., Giljum, S., de Koning, A., Lutter, S., Simas, M., Stadler, K., Wood, R., 2014. The Global Resource Footprint of Nations. Carbon, water, land and materials embodied in trade and final consumption, Leiden/Delft/Vienna/Trondheim.

UNIDO, 2011. Industrial Development Report 2011: Industrial energy efficiency for sustainable wealth creation. Capturing environmental, economic and social dividends. United Nations Industrial Development Organization, Vienna.

Wiedmann, T., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., Kanemoto, K., 2013. The material footprint of nations. Proceedings of the National Academy of Sciences (PNAS).

World Bank, 2015. World Bank Commodity Price Data. World Bank, Washington D.C.

Annexes

Annex 1: Import dependency table

Country Group	Country Name	Biomass	Non-metallic minerals	Metals	Fossil fuels
Asia	China	106	98	122	110
	Mongolia	105	1,093	95	169
	Taiwan	33	62	-	0.3
	Cambodia	108	77	-	-
	Indonesia	103	214	-	275
	Laos	120	645	-	-
	Malaysia	136	78	8	134
	Philippines	103	101	-	21
	Singapore	0	53	-	-
	Thailand	118	82	16	55
	Viet Nam	108	116	24	153
	Bangladesh	96	88	-	55
	India	102	110	112	79
	Nepal	101	102	-	1
	Pakistan	100	103	5	53
	Sri Lanka	86	97	-	-
Latin America	Argentina	125	131	-	141
	Bolivia	103	295	-	334
	Brazil	113	132	145	70
	Chile	109	751	133	8
	Colombia	103	94	15	406
	Ecuador	104	93	-	269
	Paraguay	117	84	-	-
	Peru	104	1,154	134	66
	Uruguay	140	116	8	-
	Venezuela	77	111	152	409
	Costa Rica	112	87	-	-
	Guatemala	111	106	6	21
	Honduras	102	150	-	-
	Nicaragua	126	104	-	-
	Panama	104	82	-	-
Eastern Europe / Central Asia	Russian Federation	103	134	155	196
	Ukraine	108	110	465	76
	Kazakhstan	102	199	209	279
	Kyrgyzstan	103	125	-	15
	Armenia	94	231	-	-
	Azerbaijan	94	97	2	524
	Georgia	91	147	-	3

Country Group	Country	Biomass	Non-metallic minerals	Metals	Fossil fuels
Middle East	Bahrain	7	67	-	170
	Iran	90	125	82	278
	Kuwait	12	80	-	643
	Oman	56	97	-	460
	Qatar	13	77	-	580
	Saudi Arabia	34	87	-	478
	Turkey	94	100	24	46
	United Arab Emirates	12	74	-	158
Africa	Egypt	83	123	17	121
	Morocco	94	126	3	0
	Tunisia	94	93	15	92
	Cameroon	109	95	-	219
	Cote d'Ivoire	103	108	-	93
	Ghana	115	289	-	-
	Nigeria	94	104	3	1,061
	Senegal	47	105	-	0
	Ethiopia	105	90	-	-
	Kenya	101	114	-	-
	Madagascar	103	120	-	-
	Malawi	109	98	-	12
	Mauritius	130	88	-	-
	Mozambique	118	148	-	168
	Tanzania	105	116	-	23
	Uganda	105	106	130	-
	Zambia	103	499	-	2
	Zimbabwe	109	249	52	111
	Botswana	100	202	-	37
	Namibia	143	318	-	-
	South Africa	95	226	184	211

Notes:

100% ...Material demand equals domestic extraction of materials

<100% ...Material demand exceeds domestic extraction of materials

>100% ...Material demand is lower than domestic extraction of materials

Annex 2: Share of manufacturing sector material use (in %)

Country Group	Country	Agriculture	Mining	Manu-facturing	Energy / construc-tion	Transport (incl. Trade)	Services	Total
Asia	China	8	16	51	20	2	3	100
	Mongolia	34	41	9	9	4	3	100
	Taiwan	2	7	64	19	3	5	100
	Cambodia	44	4	33	9	3	6	100
	Indonesia	19	34	28	13	4	2	100
	Laos	46	25	22	5	1	1	100
	Malaysia	22	11	39	13	10	6	100
	Philippines	32	10	38	10	7	3	100
	Singapore	1	5	62	13	10	8	100
	Thailand	26	10	41	14	7	3	100
	Viet Nam	25	24	23	24	2	2	100
	Bangladesh	51	10	15	19	3	2	100
	India	34	14	26	20	4	2	100
	Nepal	72	4	13	6	0	4	100
	Pakistan	47	12	17	18	3	3	100
	Sri Lanka	22	13	24	29	8	3	100
Latin America	Argentina	40	13	34	8	3	3	100
	Bolivia	36	22	30	7	3	2	100
	Brazil	37	6	44	5	3	4	100
	Chile	8	50	30	7	3	2	100
	Colombia	34	18	32	10	4	2	100
	Ecuador	30	19	27	18	4	3	100
	Paraguay	53	2	31	5	5	4	100
	Peru	12	56	25	3	2	1	100
	Uruguay	26	12	30	25	2	4	100
	Venezuela	18	28	36	11	6	2	100
	Costa Rica	33	10	36	12	5	4	100
	Guatemala	44	8	27	15	4	2	100
	Honduras	41	9	33	12	4	2	100
	Nicaragua	51	5	28	11	3	2	100
	Panama	27	10	19	27	12	5	100
Eastern Europe / Central Asia	Russian Federation	11	29	33	17	6	4	100
	Ukraine	22	15	38	18	3	4	100
	Kazakhstan	13	38	27	13	4	4	100
	Kyrgyzstan	39	13	18	22	5	3	100
	Armenia	21	34	27	12	3	3	100
	Azerbaijan	14	39	20	22	2	2	100
	Georgia	26	22	24	16	6	5	100
Middle East	Bahrain	0	30	36	25	5	3	100
	Iran	11	32	29	22	3	3	100
	Kuwait	0	52	21	22	2	2	100
	Oman	2	44	9	40	2	2	100
	Qatar	0	48	13	36	2	1	100
	Saudi Arabia	1	48	20	27	2	1	100
	Turkey	14	19	35	26	4	3	100
	United Arab Emirates	1	34	20	36	6	3	100
Africa	Egypt	20	25	19	27	3	5	100
	Morocco	16	20	33	18	2	11	100
	Tunisia	15	28	18	32	5	2	100
	Cameroon	41	8	31	10	7	2	100
	Cote d'Ivoire	56	9	22	8	3	2	100
	Ghana	41	23	21	11	2	3	100
	Nigeria	49	28	9	10	3	1	100
	Senegal	29	12	38	14	6	1	100
	Ethiopia	67	2	7	14	3	7	100
	Kenya	71	5	13	6	1	4	100
	Madagascar	67	4	18	7	1	3	100
	Malawi	70	4	14	9	2	0	100
	Mauritius	40	12	17	25	4	3	100
	Mozambique	53	9	17	15	4	2	100
	Tanzania	58	7	9	10	3	12	100
	Uganda	54	4	35	5	1	1	100
	Zambia	20	38	31	7	2	3	100
	Zimbabwe	47	15	27	8	2	2	100
	Botswana	22	25	23	22	4	5	100
	Namibia	24	35	23	10	4	4	100
	South Africa	12	30	33	13	5	7	100

1 http://unstats.un.org/unsd/snaama/dnllist.asp

v. 1.0 - July 2015

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
E-mail: policy@unido.org

DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH
Friedrich-Ebert-Allee 40, 53113 Bonn, Germany
E-mail: sv-nawi@giz.de

Website: **www.equip-project.org**